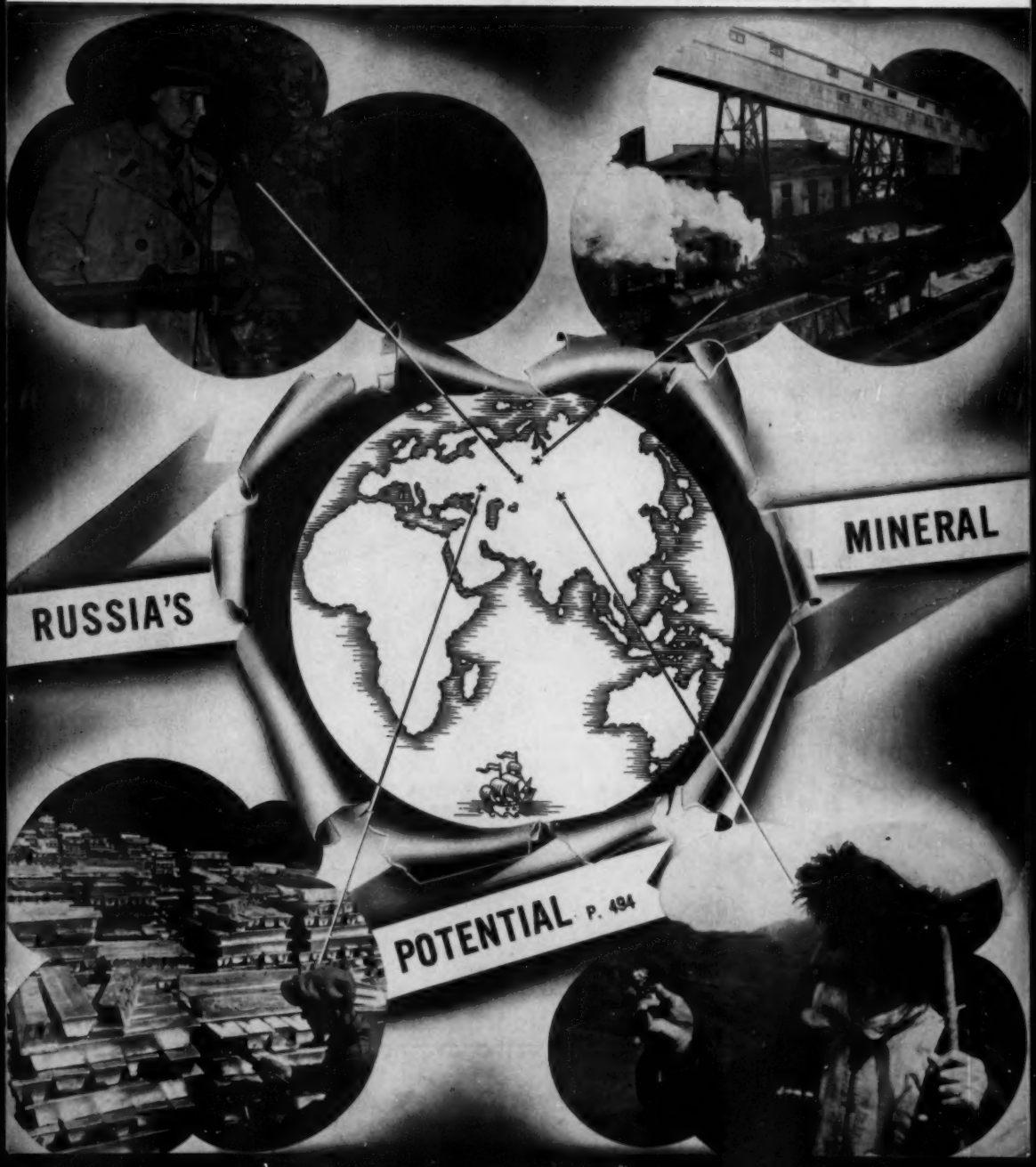
MINING ENGINEERING

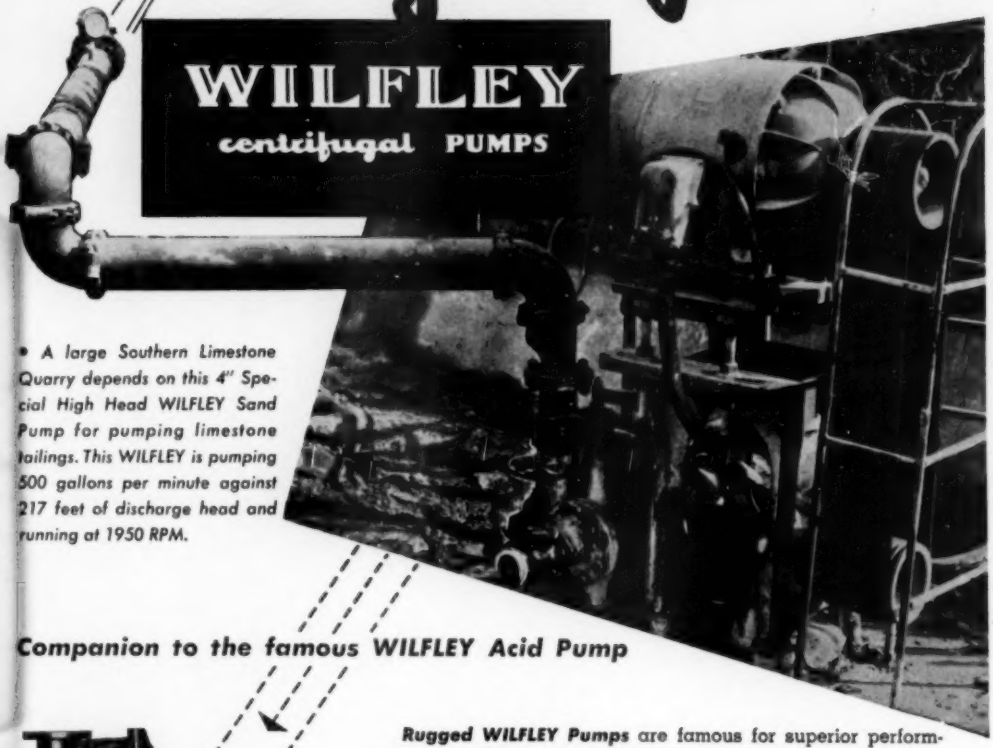
JUNE 1951
IN TWO SECTIONS—SECTION ONE



FOR

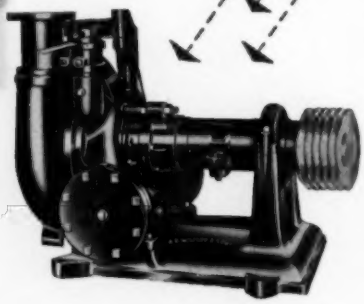
tailings disposal

WILFLEY
centrifugal PUMPS



• *A large Southern Limestone Quarry depends on this 4" Special High Head WILFLEY Sand Pump for pumping limestone tailings. This WILFLEY is pumping 500 gallons per minute against 217 feet of discharge head and running at 1950 RPM.*

Companion to the famous WILFLEY Acid Pump



Rugged WILFLEY Pumps are famous for superior performance—wherever sands, sludges, slurries, slimes or abrasive solutions of any kind must be handled efficiently and economically.

Now the new WILFLEY Model K Centrifugal Sand Pump offers important mechanical improvements—engineering refinements which save you even more dollars on the production line and in power...give stepped-up performance and low-cost operation...easy interchangeability of wear parts and low maintenance. Investigate the new Model K for trouble-free, intermittent or 'round-the-clock service on your job. Every application individually engineered. Write or wire for Bulletin 200 on the new Model K.

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Incorporating Mining and Metallurgy, Mining Technology and Coal Technology

VOL. 3 NO. 6 IN TWO SECTIONS—SECTION ONE JUNE, 1951

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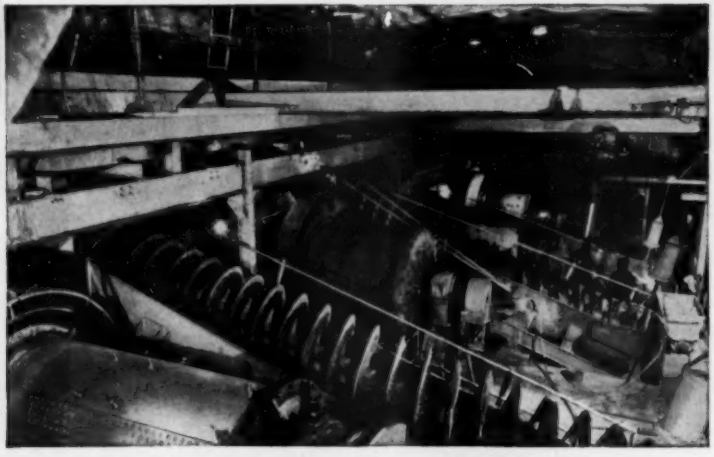
COVER: Four aspects of Russia's mineral potential, an analysis of which is given by Paul M. Tyler, beginning on P. 494. At upper left, a woman miner in a copper operation in the Urals; at lower left, aluminum ingots—products of the Dneprovsky combinate; at upper right, the Koksovaya colliery in Prokopyevsk, Kuzbass; and at lower right, a 99-year-old villager in the Tsheto-Ingush Autonomous SSR, who helps guide Soviet geologists through their vast domain.

Underground lead-zinc mill hits 1200 tons per day!

1 Hauling cars of lead-zinc ore up 15° slope to the underground mill is this 72" drum hoist, driven by G-E 300-hp 440-volt motor and control. Only one of its kind, the Gilman lead and zinc mill was built entirely underground because in the mountainous terrain surrounding it there is not enough level country. Several hundred feet down, in rooms cut out of hard rock, crude ores from the adjacent mine are concentrated for smelting at distant plants.



2 In the underground grinding room, two 100-hp and two 75-hp 440-volt G-E motors and control drive grinding mills. Classifier drives consist of four 10-hp G-E motors and control. Naturally heated to 83F, water for grinding process is pumped from mine to mill by G-E induction motors.

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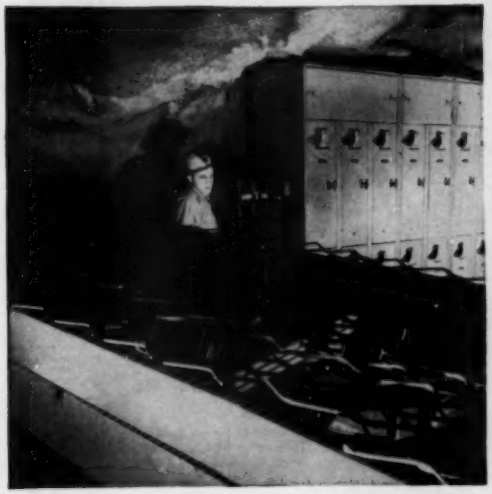
660-23

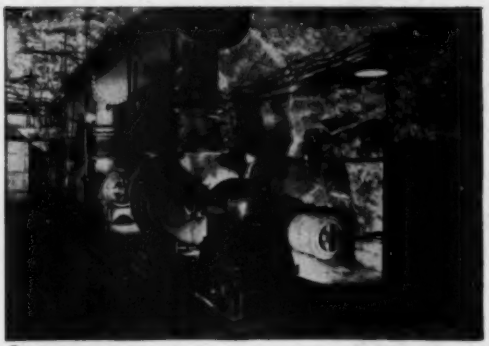
Co-ordinated G-E drives and distribution equipment help maintain continuity of production at New Jersey Zinc's unique Gilman, Colo. concentrating plant



5 **Power for the mine** comes down from the surface at 13,800 volts through 4500 feet of G-E armored cable. At this substation—comprising a G-E switchboard and three 150-kva Pyranol† transformers with gas absorbers—it is stepped down to 440 volts for utilization throughout the mine's two lowest levels.

3 **Grouped motor control** is provided at several points throughout the mill by compact G-E Cabinetrol* units. Space-saving Cabinetrol "packages" include all controls and instruments needed for various milling processes. This neat assembly, together with its associated push-button stations, is located in the mill's flotation cell room.

6 **To protect equipment** against damage from excessive overcurrents caused by heavy overloads or short circuits, the mill uses four G-E 3-pole air circuit breakers rated 600 amperes, 600 volts. G-E air-circuit breakers, selected for adequate interrupting capacity, help safeguard against loss of production in all milling operations.



4 **After grinding the ore,** lead minerals are separated from zinc minerals and waste, and then zinc minerals are separated from waste tailings in flotation cells. Air for flotation cells is supplied by these blowers, driven by three 125-hp 440-volt G-E a-c motors, with G-E control at right.

*Reg. trade mark of General Electric Co. for enclosed control panel equipment.

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At every stage in ore processing—mining, concentrating, smelting, or refining—a G-E mining industry specialist can help you solve your electrical problems efficiently, economically. He's a good man to know. Call him soon! *General Electric Company, Schenectady 5, N. Y.*

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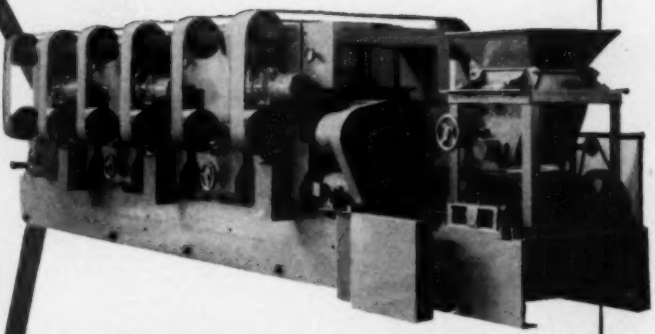

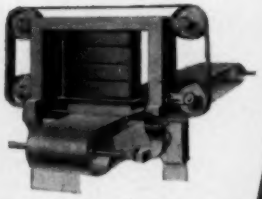

OPERATION: Material to be separated is carried on the main belt conveyor under a series of magnet and cross belt assemblies. Magnetic particles are attracted to the underside of the moving cross belt which sweeps them to the side to be separately discharged. Each magnet assembly can be adjusted to remove a desired magnetic fraction. Any number of cross belts depending on the number of materials to be separated can be provided.

Dings New Cross-Belt Type EBK Magnetic Separator Produces Highest Grade of Magnetic Concentration Obtainable

MORE selectivity and greater capacities in the concentration of magnetic ores than were heretofore possible are now obtainable with the new Dings Cross-Belt Magnetic Separator. Here are typical examples: A tungsten mining company in N. Carolina recovers 98% of a 72.2% grade WO_3 in their hubnerite ore. In McCall, Idaho, a 6 Cross Belt unit produces 550 lbs. of monazite concentrate per hour at 99.1% purity from an estimated feed of 2500-3000 lbs. of sand per hour.

Improvements

GREATER CAPACITY. New pole nose construction gives separating capacity about double that of any previous design. *Hence with this improvement, a smaller, less expensive unit will often handle requirements.* For example, under certain conditions, a new 3 Cross Belt Unit installed to concentrate manganese will do the work of a 6-belt unit of the old design.

GREATER SELECTIVITY. Each Cross Belt assembly is individually energized. The ability to make an extremely fine adjustment to each Cross Belt without affecting any other permits a degree of selective separation not possible in previous machines. A variable speed main belt drive further contributes to extreme selectivity.

EASIER MAINTENANCE. Dust sealed, anti-friction bearings are used throughout. Cross belts can now be replaced without dismantling machine.

SIMPLER OPERATION. Only one adjustment—varying the air gap—allows unit to handle various rates and qualities of feed to effect a given separation. Turning a stud, calibrated in thousandths of an inch, adjusts the air gap. Previous settings can be duplicated in seconds.

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*From Sharples Amyl Alcohols.

Bear Brand Xanthates offer the best answer to practically every problem found in the separation of sulphide minerals and in the flotation of precious metal ores. They are important because they combine good collector power with extreme selectivity. They are easily applied and act rapidly. Bear Brand Xanthates are among the most widely used flotation reagents in the world.

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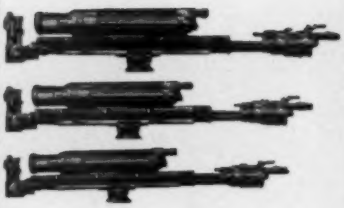
★ Air-feed sinkers — 2-way feed, 2 sizes. They take the back-breaking work out of drilling horizontal holes, lighten the load on your miners, and increase tonnages.



★ Power-feed and hand-cranked drifters. Dependable, powerful, and fast. Ideal for columns and jumbos alike.

★ A complete line of sinkers from 18 to 80 lbs. including the popular 45-lb. H10, and 55-lb. H111.

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Rock Drills You Can Count On

. . . . . fast-drilling, dependable favorites of mining men since 1906

Of course, you know that Le Roi-CLEVELAND makes the popular, easy-holding H10 and H111 sinkers... the fast-drilling FD24, 25, and 14 power feed drifters ... the S11 and SS22 stopers with tap position for easier handling . . . and a mine jumbo that lets you drill out your rounds faster, with greater safety.

But did you know that Le Roi-CLEVELAND was responsible for some famous "firsts"? Here are a few of them—work-savers that help your miners increase their man-shift pro-

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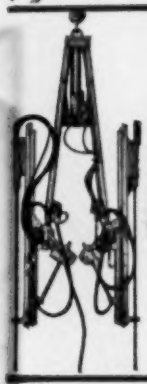
So if you have a job of drilling to do—do it with Le Roi-CLEVELAND machines. You can count on them. They're built for speed. And they're built to stay underground, too — where you can use this speed to do more work and cut your costs.

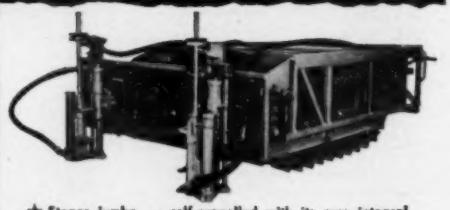
Detailed information about the complete Le Roi-CLEVELAND rock drill line is yours for the asking. Just write us.



★ The SDR 34 shaft sinker for faster shaft sinking. Fully closed it's 5'6" between drill centers; open 19'3". All adjustments quickly made with air motor.

★ Stopers for every need — the 90-lb. S11, the 120-lb. SS-22, and a complete line of offset stopers with 36-inch steel changes for deep holes, or with short feeds for confined spaces.

★ The famous MDR Jumbo with air-motor poweredbooms for quicker set-ups, greater safety, faster rounds.



★ Stoper jumbo — self-propelled with its own integral dust-collection system for positive dust control, the latest thing for roof bolting.

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Completely resistant to the chemical action of surphurous waters, alkalies, metallic salts, and other corrosive wastes, CARLON solves piping problems in surface and subsurface mining operations. This durable new pipe is **guaranteed** against rot, rust, and electrolytic corrosion, and it has a service life many times longer than ordinary pipe.

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Both flexible and rigid types of CARLON are available in standard pipe sizes. Flexible pipe is furnished in long lengths which conform to irregular surface contours or ditch lines and require fewer fittings per installation. Rigid CARLON is shipped in threaded and coupled random 21-foot lengths which can be joined quickly by means of threaded plastic fittings. To meet individual job requirements, rigid CARLON can be cut to desired lengths and threaded with standard pipe dies.

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1. High Strength per Pound of Metal Used

The *Superior* crusher has been designed by Allis-Chalmers to take advantage of the latest engineering practices, modern materials and manufacturing methods. Cast steel instead of cast iron construction makes the entire crusher highly resistant to shock. Integrally cast reinforcing rings on top and bottom shell provide high strength with an economical use of metal.

Cast steel spider arms are of box construction . . . offer greatest strength and least interference for feed. Spider is fully protected by rim and arm liners. Mainshaft is annealed forged steel. Concaves are manganese steel. The eccentric has a replaceable bronze inner sleeve and bottom shell bushing. Bevel gear and pinion are heat treated steel with spiral cut teeth.

2. High Capacity per Pound of Metal Used

As high as 3040 tons of stone or ore per hour can be crushed in the 60-89 *Superior* crusher (60-in. receiving opening). High capacity design includes: straight down discharge, eliminating need for diaphragm . . . a countershaft that runs at available motor speeds . . . a deep crushing chamber that is the result of over a half century of experience in building gyratory crushers.

The shape of this scientifically designed curved crushing chamber offers a broad area of breaking contact, which spreads wear over more surface. The crusher setting can be maintained over long periods. Changing the lower tier of concaves makes it possible to get various initial settings without changing the angle of nip — a big advantage.

3. Vertical Adjustment to Compensate for Wear

To compensate for wear on mantle and concaves, the *Superior* crusher has been designed so that the mainshaft can be raised with respect to the concaves. This is made possible by a long threaded portion of the mainshaft and a cast steel adjusting nut supported in the spider hub. The curved crushing chamber, moreover, has been designed to utilize this vertical adjustment to the fullest extent in compensating for wear.

The original discharge setting can be maintained, for all practical purposes, throughout the life of a single set of crushing surfaces with no more than one resetting of the concaves.

A-3316

Improved Lubrication System, Dust Seal

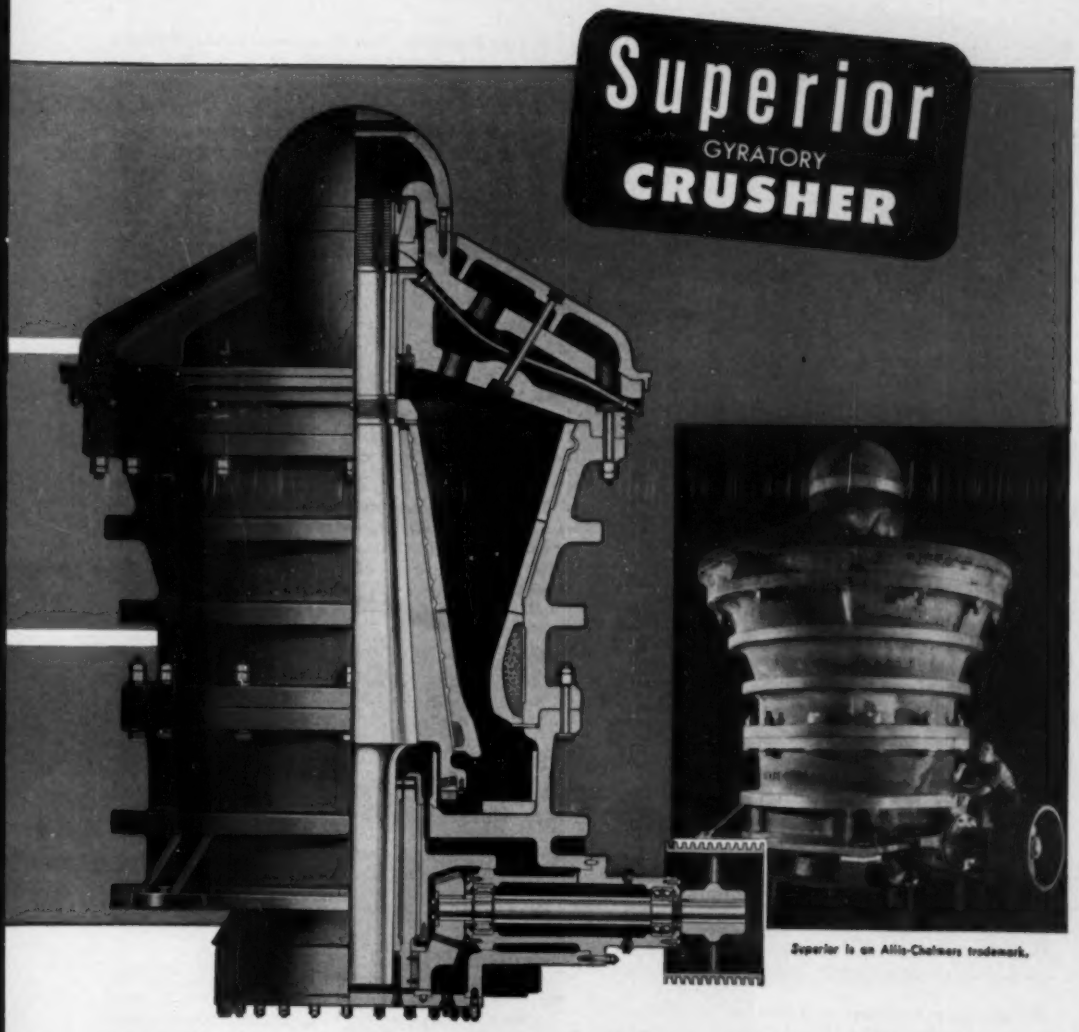
A fully automatic lubricating system consists of a tank, oil pump, motor, pressure type oil filter and condenser type cooler, all external to the crusher for better accessibility. Oil from tank is pumped through filter and cooler to the crusher, lubricating the eccentric wearing plate, then the inner eccentric bearing. It returns down the outer eccentric bearing, lubricates gear and pinion and returns to tank. Oiling system has protective flow and temperature switches.

An improved dust seal consists of a moulded fabric ring enclosed in a steel housing accommodating the vertical adjustment of the crushing cone as well as the gyrating and turning of the head.

More facts about the *Superior* crusher can be obtained from the A-C representative in your area. Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-

Primary Crusher
IMPORTANT ADVANTAGES?



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MEN AVAILABLE

Mining Geologist, 38, married, one child. Sixteen years' experience exploration, development and practical mining operation and administrative work. Prefers southwest or western U.S. Would consider some foreign locations. M-622.

Mineral Economist, 28, married, B.S. mineral economics and geology, Penn State College; M.A. resources and economics, University of Texas. Experienced coal mining, concentrating plants and manufacturing of copper products. Desires responsible position mining or iron and steel industry in sales engineering or other specialized work relating to this field. M-624.

Geologist, 29, M.S. geology, married, one child. Two years resident geologist at large open pit eastern metal mine; some underground experience base metal mines. Available July 1. Prefer northeast or northwest U.S.; will consider other locations. M-625.

Mining Engineer, 47, married. Twenty-two years' experience bituminous coal mines in Ill., Ind., Ky. and W. Va., familiar with mechanized mining in 36 to 84-in. seams. Prefer Midwest, West or East. Available 2 weeks. M-626-23MW-Chicago.

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Mining Engineer, 32, recent graduate. One year coal mining experience; 3 years' precision work in machine shop; design and layout 6 years, tooling, machinery, cement plants. M-628.

Engineer, 37, married, 3 children; B.S. in metallurgy. Presently and for past eight years mill superintendent for 750 ton per day concentrator. Four years' experience ore testing laboratory. Available August. Interested only in western United States. M-630

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Metallurgical Engineer with several years' experience in ore concentration. Work to be mill operation and some development. Expanding organization. Salary, to $6000 a year. Location, Southeast. Y5405.

Chief Geologist, Assistant Geologists and Geophysicists for bringing into production new properties in Bolivia. Will examine prospects and attempt to find completely new mines. In addition to tin and base metals, attention will be paid to nonmetallics as well as minerals not generally recognized by average prospectors. Salary open. Y5384.

Mining Engineer, 30 to 40, with three to five years' mining experience, preferably in mica, also with some knowledge of flotation and purification processes. Salary open. Location, Ohio. Y5362.

Mine-Mill Supervisor, to take charge of fully integrated silica sand operation. Rated capacity 400 tons a day. Requires ability to coordinate operations, supervise production staff, improve production methods and product. Technical knowledge of milling required, plus supervisory experience. Salary, $4200-$4800 a year. Location, Canada. Y5299.

Geologists with some experience, or master's degree, for diamond drilling, mapping, etc., on iron ore project. Single status for two years. Salary, $4200-$4800 a year. Location, Venezuela. Y5291.

Lubrication Sales Engineer, 32-40, with experience in sales of industrial and automotive lubricants, to sell lubricating oils and greases throughout Latin America. Considerable traveling. Must have knowledge of Spanish. Salary, $7200 a year plus expenses. Y5204.

Mining Engineer to work in the technical end of conveyor belt division. Some mining experience or experience with belt conveyors in mining operations advantageous. Will, after training, make outside contacts with companies in connection with requirements for conveyor belts. Salary, $3600-$4200 a year. Location, Ohio. Y5199D(b).

Mining Engineer, young, preferably with 1 to 4 years' underground experience. Should be interested in mine geology, operational planning, time studies and mine structural design. Salary, $3900-$4800 a year to start, depending on qualifications. Traveling expenses paid. Location, New Jersey. Y5070.

Engineers. (a) Mill Superintendent with minimum of five to ten years' experience in the operation of a mill for metal mining company. (b) Assistant Mining Engineers for metal mining operations in the Philippine Islands. Salaries open. Y5022.

Superintendent to take charge of a mine and mill at copper, silver and gold property. Salary open. Location, Montana. Y4975.

Engineers for Large Mining Company. (a) Mechanical engineer, graduate, 28-40, to assist chief engineer of large hydrometallurgical plant, direct design, make recommendations to improve equipment. Salary, about $6000. (b) Field engineer, civil engineer, 28-40, to be in charge of new construction, field layout and erection projects planned. Salary, about $6000. (c) Office engineer, mechanical, 28-35, to be in charge of drafting room. Will work with mechanical engineers, electrical engineers in completing the design and development of machinery and equipment. Salary, about $6000. (d) Electrical engineer, graduate, 30-40, to be responsible for elec-

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With just two fingers, your operator easily controls the single throttle lever on the Gardner-Denver Airslusher. Yet this load-lugging double-drum slusher hoist hauls a full pay load every trip — hurries the scraper back to the muck pile — pronto!

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trical engineering design and maintenance of power system, switch, gear and controls. Experience in meters and electrical distribution precipitation desirable. Salary, $6000. (d) Mine superintendent, B.S. or E.M., age to 40. Must have experience in open-pit dragline, stripping and mining, to plan and supervise mining truck haulage and railroad in extracting 5000 tons per day. Salary, $8400. (f) Draftsmen, experienced in pipe layout, structural and plant design. Salary to $5000. Spanish desirable in all of these positions. Excellent family housing available; healthful climate, good living and recreational facilities. Location, eastern Cuba. Y5396

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or

SUBSIDER

or

THICKENER

30 to 36-ft diam, approximate capacity 100,000 to 140,000 gal, 4 to 6 tray type. New or used in excellent working condition. Airmail offers to Mr. O. Ugarte, P.O. Box 1348, Havana, Cuba, stating price, measurements, type, location, delivery date as well as all available data, and enclosing sketch.

Designers, Draftsmen Wanted

Designers & Draftsmen with experience in ore dressing plants, smelters and related machinery wanted for permanent positions with active engineering and manufacturing organization. Location: East, Middlewest, West. Salary based on experience. Mail full details of training and experience to P-4, MINING ENGINEERING.

GRADUATE MINING ENGINEER

30 to 40 years of age. Must have broad experience in general coal mine engineering, will assume charge of underground surveying, map work and general engineering as assistant to plant engineer. Mine completely mechanized, located at Harewood, W. Va. Give experience, education, age, references, personal history. Be complete and specific. All inquiries will be handled promptly and confidentially.

SEMET-SOLVAY DIVISION

Allied Chemical & Dye Corporation

Box 670 Bluefield, West Virginia

CIVIL SERVICE EXAMINATION
GEOLOGISTS—$4600 to $7600
(Grades GS-9 to GS-13)

Optional fields: mineralogy and petrology, geomorphology and glaciology, geology of metallic and nonmetallic mineral deposits, sedimentation, stratigraphy, paleontology, ground water geology, geology of fuels, general geology, engineering geology, mining geology. *Basic requirements:* B.S., with courses in geology and 30 hours of practical work; *or* 30 semester hr of geology courses plus geological experience to provide background approximating that of college graduate. Applications available at post offices, or Civil Service Commission Regional offices. Announcement No. 287. Open until further notice.

WANTED

IMMEDIATELY for extensive Diamond Drilling Program in Bolivia—a general foreman to supervise work and two assistants. Salaries depending on experience, $400 to $500 monthly, with transportation both ways. Latin American experience desirable but not essential. Send complete record, plus references to South American Minerals & Merchandise Corp., 445 Park Ave., New York 22, N.Y.

Metallurgist-Mill Foreman, college graduate, experienced ore dresser and mill operator, standard three-year contract, salary $5500 yearly, plus bonus one month yearly, single status or if married single status for six months, working knowledge Spanish essential, free transportation to Bolivia by air for employee (and wife if married), four weeks' vacation yearly, free living quarters. Box E-8, MINING ENGINEERING.

Mining Engineer with 2 years' minimum practical underground or open-pit experience to supervise special projects and miscellaneous mining work. Open-pit, nonmetallic, location California. Good opportunity. State full details including experience and references.

Box E-11, MINING ENGINEERING

Mining Geologist with a minimum of two years' experience to assist chief geologist of an open-pit, nonmetallic operation in California. Geological drafting, mapping, logging diamond drill core, field work, field mapping and sampling. Good opportunity. State full details including experience and references.

Box E-12, MINING ENGINEERING

CHIEF ENGINEER

Thoroughly experienced engineer with background of mine layout, mill design (both new construction and revamping), structural steel and concrete work, to head up engineering department of nonmetallic underground mining and milling operation of medium size. Preferred age 30 to 40. Should be able to pass State examination for licensed civil engineer. Housing available. Location western state. When replying give complete experience record and state salary expected.

Box E-9, MINING ENGINEERING

DRAFTSMAN

With experience in plant layout and detail. Must be good in concrete and steel structure detail and with knowledge of dry conveying equipment. Salary $375.00 per month. Single status preferred. Location western state.

Box E-10, MINING ENGINEERING

ASSISTANT SAFETY ENGINEER

Two years' accident prevention work in mining, tunneling, or quarry, or 4 years' engineering experience in these fields. Engineering degree required. Additional qualifying experience may be substituted for college on a year-to-year basis. Salary $358 to $436. Inquire State Personnel Board in San Francisco, Sacramento, or Los Angeles. Applications accepted up to midnight June 30.

FROM INGOT TO FINISHED ROPE:

there are no gaps in our

Quality Control

Quality control of Wickwire Rope is *complete and uninterrupted* from the actual smelting of our own iron and steel to the final making of the finished rope.

Only a company like C. F. & I. with its constant checking, testing and inspection through every step of manufacture can give you the big advantages that are derived from a constant and uniform size of steel grain in each grade of finished rope wire. When you specify Wickwire Rope you're sure of wire rope that's unequalled for safe and unfailing performance . . . longer, more economical and uniform service on the job.

LOOK FOR THE YELLOW TRIANGLE ON THE REEL

WICKWIRE ROPE CF&I

A PRODUCT OF WICKWIRE SPENCER STEEL DIVISION OF THE COLORADO FUEL AND IRON CORPORATION

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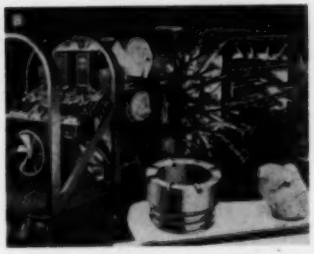
PACIFIC COAST SUBSIDIARY—The California Wire Cloth Corporation, Oakland 6, California

Manufacturers News

New Products • *FILL OUT THE COUPON FOR MORE INFORMATION* • Equipment

Fast New Mining Machine

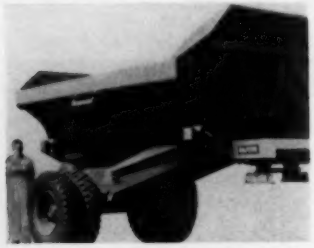
A completely new design of mining or tunneling machine developed by The Demo-Canon Engineering Co., is now undergoing extensive testing. Drill heads are furnished for the machine by the Tilden Tool Co. and are truncated core shafts with



specially treated sintered carbide cutters, stress relieved. The drilling machine is designed so that it may be mounted on a mine flat car or suspended from a mono-rail track attached to the roof of the tunnel. The entire structure is mounted as a unit on a channel iron base and rigid framework. The operator sits in an enclosed cab with the driving controls arranged before him on a console. The experimental model, shown here, carries 28 drills in a rack-like structure. It is said to be capable of working the entire face of a tunnel in a single operation. Test records indicate that the machine will increase tunnel driving speeds up to 80 pct. **Circle No. 1**

Side Dump Trailers

Model TP doorless pan-type trailers manufactured by Eastern Car & Construction Co. may be dumped to either side. The body may be reversed from end to end to prevent excess wear on one side. The trailer is furnished with one bolt-attached



stabilizer arm, interchangeable from side to side, depending upon the direction of dumping. The new all-welded body design features a new and stronger edge construction. A 3-in. floor cushion and replaceable carbon steel liner plate protect and reinforce the body floor. Load distribution has been improved to place more load on the fifth wheel, thus providing better traction on the tractor axle. **Circle No. 2**

New Tournadozer Features

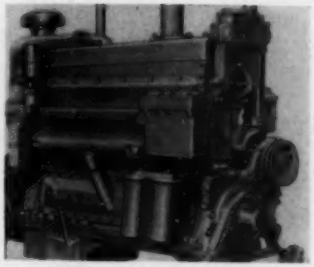
R. G. Le Tourneau, Inc., manufacturers of heavy earthmoving equipment, are now building the "Super C" Tournadozer available with torque converter and electric control. The torque converter transmits and selects the proper ratio for delivering power in a steady, even flow to the wheels and provides a shock load cushion between the engine and the drive wheels which allows the engine to operate at maximum rpm. Lugging of the engine is eliminated. The various gears in the constant-mesh, air-actuated transmission now are controlled by electro-magnetic valves placed in the air lines going to the clutches which engage the transmission gears. These valves are controlled by four push-pull finger tip switches mounted on the dash panel. **Circle No. 3**

New Ladder Stabilizer

The Hydra-Lizer (hydraulic ladder-stabilizer), distributed by Mine Safety Appliances Co. is an adjustable steel attachment for the lower end of straight or extension ladders. With this stabilizer a ladder remains firm and steady in any position on steps or sloping terrain. The vertical tubes which house the legs or plungers are cross-connected near their upper ends by steel telescoping valve tubes leading to a central valve block. The valve assembly adjusts to any ladder width between 17 and 29 in. and fits straight, as well as flare base, ladders. **Circle No. 4**

Industrial Diesel Engines

The D337 and D326 Caterpillar Diesels, scheduled for production this year, incorporate several innovations. One new feature on the two models is the fuel system with fuel pumps mounted adjacent to the cylinders they serve. This results in standard, identical, short fuel lines for each cylinder. A completely redesigned 25-hp vertical gasoline



starting engine is used which has several new design features to provide easier starting. **Circle No. 5**

Lightweight Belt Conveyor

Speed is one of the many features of the lightweight troughed belt conveyor that introduces Fairfield Engineering Co.'s new line of portable conveyors. Model 666 handles 75 yd

of sand or gravel per hr, and can also handle ore, lime, cinders and other materials. Standard equipment consists of a twin hydraulic boom hoist, underslung axle, slide trough, and a 14-in. four ply belt. Lengths from 14 to 25 ft are available. **Circle No. 6**

Directional Dirt Collector Combats Air Pollution

A new instrument for use in analyzing air-pollution problems in highly industralized areas has been developed by Battelle Institute. The dirt-fall collector is designed to collect heavy dirt from any direction the wind is blowing. A so-called "wind-rose pattern" shows the number of hours the wind has blown from the eight points of the compass. Knowing this, it is then possible to determine the relative amounts of dirt which have fallen per hr into the instrument from the various directions. **Circle No. 7**

Free Literature

(8) FLUOSOLIDS SYSTEM: Bulletin 7500 "FluoSolids Roasting of Sulphides" issued by *Dorr Co., Inc.* covers briefly the use of the Dorrco FluoSolids system as an economical means of producing SO_2 from pyrite or pyrrhotite to supplement presently short supplies of elemental sulphur. In utilizing the principle of fluidization, this system brings the production of SO_2 from sulphides down to a reasonable investment and operating cost level.

(9) ROLLO VALVES: These valves for viscous liquids and liquids with solids are described and illustrated in pamphlet W-404-B4 available from *Worthington Pump & Machinery Corp.* The valve cover is heavily constructed of drop-forged carbon steel and acts as spring retainer and stop for the valve. Corrosion resistant 18-8 stainless steel, ground flat on ends, is used for the spring. These and many other advantages are featured in the pamphlet.

(10) FURNACES: Complete line of furnaces for every tool room heat treat requirement is illustrated in booklet SC-151 released by *Surface Combustion Corp.* Emphasizing methods of precise heat treatment for maximum tool life, this bulletin describes controlled atmosphere furnaces and generators in addition to direct-fired, forced convection and pot furnaces. Hardness conversion table is also included.

(11) MINE VENTILATION: New revised brochure obtainable from *Bemis Bro. Bag Co.* contains uses of Bemix Flexipipe for ventilating coal mines, metal mines and tunnels. Detailed information and photographs describe installation of the Flexipipe size and lengths available, and the two types of couplings supplied are included.

(12) SPEED REDUCERS: Bulletin A602 gives data relating to the single reduction series of the *Dodge Mfg. Corp.* Torque-Arm reducers. Comprehensive data in tabular form is included so that quick selection of the right reducer for any installation can be made if the hp required, and the speed and size of shaft to be driven is known.

(13) COUPLING SPECIFICATION: These specifications follow recommendations of the AISI, American Petroleum Institute, and the Assn. of American Railroads. Sheet 451-C listing dimensions of line, railroad, merchant, water well, and other pipe couplings is offered by *Capitol Mfg. & Supply Co.*

(14) OPTICAL PARTS: Catalog published by *Bausch & Lomb Optical Co.* contains information of use to engineers and designers. By consulting this catalog in initial stages of instrument development, standard optical parts can often be incorporated into design and avoid cost of tailor made optics. Lenses, prisms, reflectors, and miscellaneous optical parts are illustrated and listed with all pertinent data.

(15) CHAIN DRIVE: Revolutionary power transmission chain drive is completely described in catalog C 72-51 issued by *Morse Chain Co.* Featuring entirely new design principles and called Morse Hy-Vo (high velocity) chain drive, it provides a power transmitting medium that combines ruggedness and dependability of a gear drive with smoothness and lack of vibration of a belt. This makes possible single drive units capable of transmitting as much as 5000 hp at linear speeds up to 6500 fpm, or rotative speeds up to 36 rpm.

(16) HOSE COUPLINGS: Complete line of couplings and fittings offered by *B. F. Goodrich* illustrated in bulletin 3100. Cross-sectional photographs and dimensional tables are given on various types available. General coupling recommendations are also included.

(17) DIESEL SETS: Design, operating and performance features of *Caterpillar Tractor Co.'s* four largest diesel electric sets are presented in 16-page booklet 30059 issued by the company. Power ranges from 314 kw model D397 to 165 kw model D364 (rated output) are outlined and information is given as to the easy adaptation of the engines for various jobs. Included are features of construction, operation, cooling, and lubrication. Fuel consumption specifications are also noted.

(18) STEEL SHEETING: Sheeting used for trenches, cofferdams, cut-off walls, and shore protection is described in manual Sh-4650 available from *Armco Drainage & Metal Products, Inc.* Sheeting may be used as a permanent or temporary means of retaining earth or water. Illustrations show various uses to which this sheeting can be put.

(19) DISC FILTER: Filters used by metallurgical, paper, cement, chemical, and coal industries are presented in pamphlet offered by *Denver Equipment Co.* Capacities, dimensions, specifications, and cross-sectional data are given.

(20) NEW COMPACT COMFO RESPIRATOR: Provides protection for workers in industries where toxic or fibrosis-producing dusts are hazards. The redesigned respirator features a new type mineral wool filter which requires less than half the filter area and offers only half the breathing resistance of previous models with the same dust collecting efficiency. The perforated metal filter covers are designed to snap on and off the filter holder enabling speedier changing of filters. The covers come off when pressed in the center and snap on when pressed at the sides. Bulletin CR-26 is obtainable from *Mine Safety Appliances Co.*

(21) PROTECTIVE EQUIPMENT FOR WELDERS: Describes and illustrates a wide range of eye protective devices for both gas and arc welding, and includes product information on respiratory protection for welders. Accessories such as rubber mask padding for goggles, and the Weld-Aid lens for welders who wear bifocal glasses are also described. This 4-page circular is issued by *Wilson Products, Inc.*

Mining Engineering **June**
29 West 39th St.
New York 18, N. Y.

Please send me { More Information ☐ / Free Literature ☐ / Price Data ☐ } on items indicated.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
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31	32	33	34	35	36	37	38	39	40

Students are requested to write directly to the manufacturer.

Name_____ Title_____

Company_____

Street_____

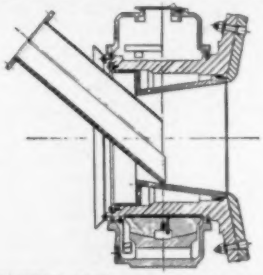
City and Zone_____ State_____

Engineered for *Grinding Mills*

TRUNNION BEARING

EXTRA LARGE — Diameter of king-size Allis-Chalmers trunnion bearing is almost twice the bearing length, large enough to permit spout feeding. Large bearing proportions will provide long service despite heavy-going demands on mill. Internal oil system can be checked visually by means of hinged flap on bearing housing.

LOW BEARING PRESSURE — A spherical seat keeps mill in perfect alignment with bearings. Load is distributed evenly across full face of bearing, reducing wear. Cooling coils embedded in babbitted bearing cool the oil at point where most heat is generated. Piston ring seals hold oil in and dirt out . . . oil supply is always clean.



LONG BEARING LIFE — Internal oiling buckets carry lubricant to oiling pan. Oil is supplied the instant mill is started. All large bearings are fitted with lubricant pump for floating the mill during starting. This overcomes high starting torques and eliminates "dry" starting after shut-downs, which causes about 75 percent of bearing wear.

During normal operation, a film of lubricant separates trunnion from bearing. No metal to metal contact.

After a short shut-down period the thickness of this protecting film of lubricant is reduced.

After long shut-down, lubricant film is broken entirely. The result is damaging metal to metal contact between trunnion and bearing.

Lubricant pump floats the mill before starting . . . re-establishes protecting film of oil. Power needed for starting is greatly reduced, too.

Additional facts about trunnion bearings and other modern features of Allis-Chalmers grinding mills may be obtained without obligation from the A-C representative in your area or by writing to: Allis-Chalmers, Milwaukee 1, Wisconsin.

A-3248

Texrope is an Allis-Chalmers trademark.

Trunnion bearings are built by Allis-Chalmers in 10 sizes from 14 x 8 to 54 x 22-in. The six smallest sizes are available as grease lubricated bearings; seven largest sizes as oil lubricated bearings.

ALLIS-CHALMERS

Sales Offices in Principal Cities in the U. S. A. Distributors Throughout the World.

Motors

Controls

Texrope Drives

Vibrating Screens

Crushers

Kilns, Coolers, Dryers

Case histories prove longer life

These actual service tests, involving the crushing of millions of tons of ore, represent data on which you can rely. Years of service have confirmed the results of this carefully-run test.

Case No. 1

Tests in Colorado between 1938-40: Molybdenite ore—quartz and feldspar, principal abrasives.

Service: Marcy 9′ × 9′ Trunnion overflow type ball mills grinding minus ¾″ siliceous ore to 62% minus 100 mesh. Mill pulp density 75% solids. Mill speed 20 rpm: balls charged were 3″ dia.

Comparison: Under similar conditions, between two sets of manganese steel liners and six sets of high carbon chromium-molybdenum steel, (normalized and tempered to average 360 Brinell).

Liner type: Shell (Barrel liners), ship lap type; weight 33,500 lb. approx. per set.

Results:	*Hours in Service*	*Net Wear Lb/Hr**	*Per cent Scrap*
Manganese steel (average of two sets)	4979	4·59	34·2
Cr-Mo steel (average of 6 sets)	5561	3·97	34·3

* Net wear per hour represents metal actually worn away.

The manganese steel liners wore 16% faster than the chrome-molybdenum steel liners.

Case No. 2

Tests in Colorado, 1943: Molybdenite ore—quartz and feldspar, principal abrasives.

Service: Marcy 9′ × 8′ grate discharge type ball mills grinding minus ¾″ siliceous ore to 55% minus 100 mesh. Mill pulp density 75% solids. Mill speed 20 rpm: balls charged were 3″ dia.

Comparison: Under similar conditions between two sets manganese steel liners and eleven sets of high carbon chromium-molybdenum steel, (normalized and tempered to average 400 Brinell).

Liner type: Shell (Barrel liners), ship lap type of special thin design for high capacity mill operation; weight 26,000 lb. approx. per set.

Results:	*Hours service*	*Net Wear Lb/Hr*	*Tons Ground*	*Net Wear Lb/Ton*	*Per cent Scrap*
Manganese steel (Average of 2 sets)	2441	6·14	209824	·0715	38·7*
Cr-Mo steel (Average of 11 sets)	3018	5·02	249002	·0616	42·8

* worn beyond desired limits.

The manganese steel liners wore 22% faster (per hour basis) or 16% faster (per ton basis) than the chrome-molybdenum liners.

Write for 32 pp reprint of an informative paper published by the Amer. Inst. of Mining and Metallurgical Engrs., giving results of wear tests on grinding ball materials—FREE!

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C12

Meet The Authors

MR. AND MRS. MEIN

V. T. STRINGFIELD

W. LOBLOWITZ

W. W. Mein *(The Calaveras Cement Co. Dust Suit,* P. 534) became vice president and assistant to the president of Calaveras Cement Co. after holding various jobs since 1932 at the plant and San Francisco office. He is also vice president and director of the Bishop Oil Co., for which company he has done geological work in Oklahoma. Mr. Mein, who attended the Buckley School in New York, and the Potter School in San Francisco, holds a B.S. in engineering sciences from Harvard.

V. T. Stringfield *(Economic Aspects of Groundwater in Florida,* P. 525) has been with the U.S.G.S. since 1930, and is now chief of the groundwater geology section. Born in Franklinton, La., he attended high school there and went on to Louisiana State and Washington University, taking B.S. and M.S. degrees. He taught at Washington University and at Oklahoma A&M, and was an assistant professor at the New Mexico School of Mines from 1928 to 1930.

W. Loblowitz *(Beaker Flotation as a Quantitative Tool in Flotation Testing,* P. 522) is a research specialist with the bureau of mineral research at Rutgers University. Before joining the Rutgers staff, he worked at mines in Spain and Bolivia, and was a metallurgical engineer for the U. S. Metals Refining Co. at Carteret, N. J. Mr. Loblowitz was born in Czechoslovakia, and took his B.S. degree from the Polytechnische Hochschule in Brno.

P. M. Tyler *(Russia's Mineral Potential,* P. 494) has spent more than 32 years in Government work, and during that time has written "a good many hundred" technical papers, Government publications, and trade journal articles. He graduated from MIT in 1912, worked at mining and smelting operations for 2 years, and joined the Government's Tariff Commission during the War. Later he went with the Bureau of Mines as eastern regional engineer. During World War II he headed laboratory and prospecting investigations in 21 eastern states for the Bureau. In 1949 he traveled 24,000 miles through Western Europe, Greece, Turkey and French Africa as an advisor for ECA. Mr. Tyler's book, *From the Ground Up,* containing basic facts and figures on the mineral industries, is a well-known volume.

Granville S. Borden *(An Income Tax Program for Mineral Producers,* P. 503) last wrote for us on the subject of taxation in our April 1950 issue *(Taxation vs Mineral Resources).* He learned about mining the hard way, by working as a mucker before taking his B.S. from the University of California. He entered World War I as a buck private, emerged a second lieutenant, and then went to work for the Tax Bureau in Washington. At the same time, he studied for his L.L.B. and L.L.M. degrees at George Washington University. Mr. Borden, an AIME member, is now a valuation engineer and special attorney for the Bureau of Internal Revenue, and a tax counsel for various companies.

M. R. Geer *(Efficiency and Sharpness of Separation in Evaluating Coal-Washery Performance,* P. 507) has been a mining engineer with the Bureau of Mines in Seattle since his graduation from the University of Washington in 1935. He is particularly interested in coal preparation and utilization, and has made several noteworthy contributions to AIME literature on the subject, including a chapter in the "Coal Preparation" volume. Born in Delta, Ohio, Mr. Geer attended high school there, then went to Ohio State and the University of Washington for his B.E.M., M.S., and E.M. degrees.

H. F. Yancey *(co-author with Mr. Geer,* P. 507) supervising engineer for the Bureau of Mines at University Campus in Seattle, has been with the Bureau in various capacities since 1917. Beginning as a junior chemist in radioactivity in Golden, Colo., he was later assistant chemist at Urbana, Ill., and then associate chemist in Pittsburgh. Later he joined the Northwest Experiment Station in Seattle. Dr. Yancey attended the University of Missouri and the University of Illinois, taking his Ph.D. in 1923.

(Continued on page 480)

HARDHED
Diamond
DRILL BITS
J. K. Smit manufactures the largest variety of diamond bits to give you the lowest cost per foot under all drilling conditions.
HARDHED matrix for the usual drilling conditions.
HARDHED "40" matrix for abrasive conditions.
HARDHED "55" matrix for extremely difficult drilling conditions such as badly broken, hard formations.
PERRET impregnated bits where this type gives better performance than surface set whole stone bits.
J. K. Smit engineers welcome the opportunity to discuss your drilling problems. Special equipment can be made to meet any unusual conditions.
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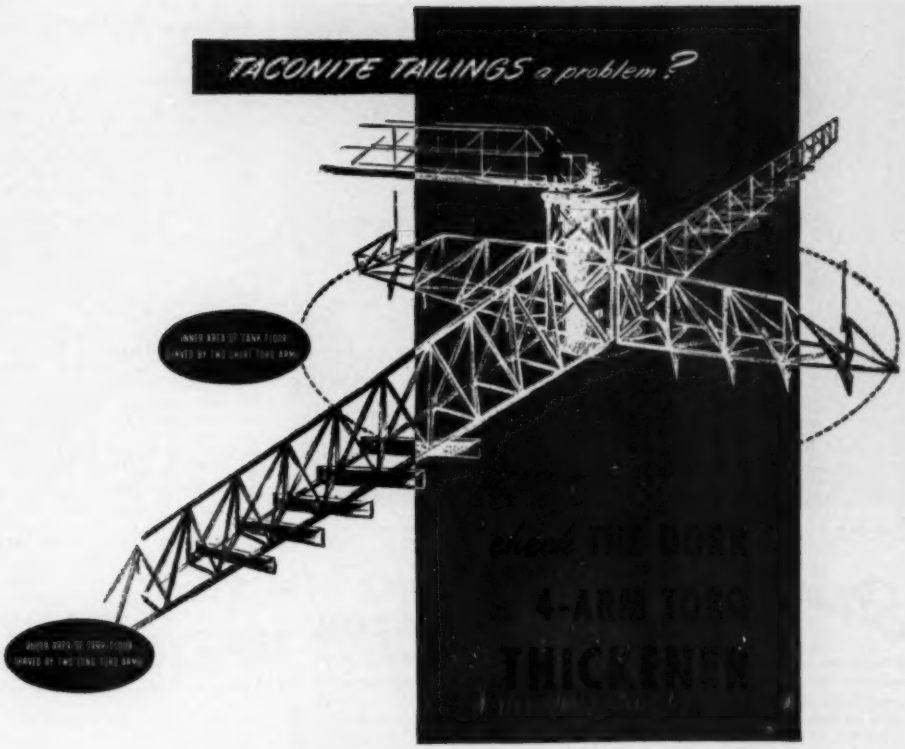


The heavy-duty 4-Arm Dorr Torq Thickener is a natural for the job of dewatering taconite tailings—or those of any heavy ore. Here's why . . .

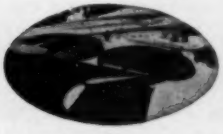
Raking load is distributed between two sets of arms . . . one long and one short . . . both utilizing the self-lifting Torq principle. The long arms rake the outer section of the tank floor. The short arms take over the load in the inner section, raking the solids to a conventional center-cone discharge. Each set of rakes functions independent of the other.

The short arms can take the heavier loads near the discharge cone in stride. Mechanically, this means uninterrupted operation—real overload protection—and easier start-ups after enforced shutdowns.

A Dorr engineer will be glad to give you detailed information.

Torq is a trademark of The Dorr Company, Reg. U. S. Pat. Off.

SUB ZERO weather a worry?



If you're concerned about cold weather Thickener operation, why not let us tell you what we've learned from big tailings Thickeners operating under sub-zero conditions on other types of work. The problem can be licked!

BETTER TOOLS *today* TO MEET TOMORROW'S DEMAND

DORRCO

DORR

WORLD - WIDE RESEARCH · ENGINEERING · EQUIPMENT

THE DORR COMPANY · ENGINEERS · STAMFORD, CONN.
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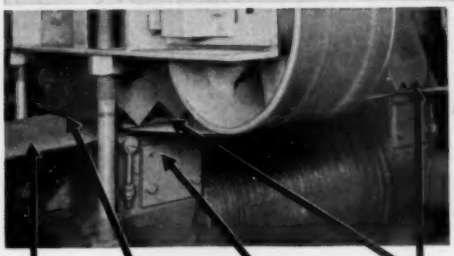
Improved Magnetic SEPARATOR for CONCENTRATION and BENEFICIATION of

HUBNERITE
ILMENITE
MONAZITE
CHROMITE
GARNET
WOLFRAMITE
and SIMILAR
MINERALS

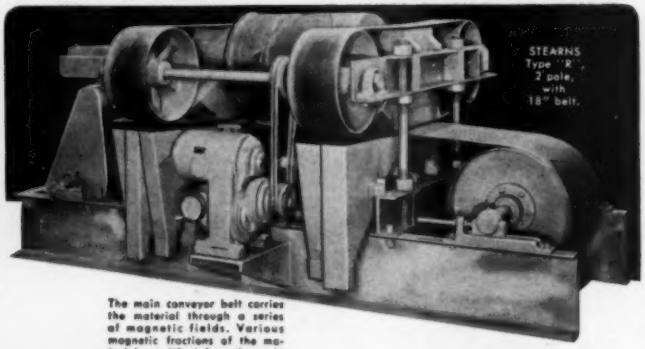


Stearns CROSS-BELT SEPARATOR

Utilizing the time-tested lift method of magnetic separation, the STEARNS Type "R" Separator has been re-designed to provide additional and improved separations of magnetically reluctant ores and minerals at a lower total cost. These results have been achieved mainly through a multiple point adjustable pole construction* which will give up to four different and distinct magnetic products at each pole. Thus, fewer magnet assemblies are required and therefore the initial and operating costs are reduced.

Having multiple magnetizing zones of increasing intensity in a single field not only provides (1) the time necessary to overcome the magnetic reluctance, but (2) also provides for a self-induced magnetizing effect on the ores and minerals as they pass from zone to zone of increasing magnetic intensity.

By adjusting the angle of the lower pole it is possible in most applications to use a single magnet separator having as many or more separating zones as would ordinarily be found in a separator having a multiple of magnetic fields. Write for complete descriptive literature on STEARNS Separators for mining applications.



The main conveyor belt carries the material through a series of magnetic fields. Various magnetic fractions of the material are lifted from the main belt and carried away by the cross belt assemblies.

*Patent No. 2511484

Stearns MAGNETIC MANUFACTURING CO.
679 S. 28th St., Milwaukee 46, Wis.

Authors

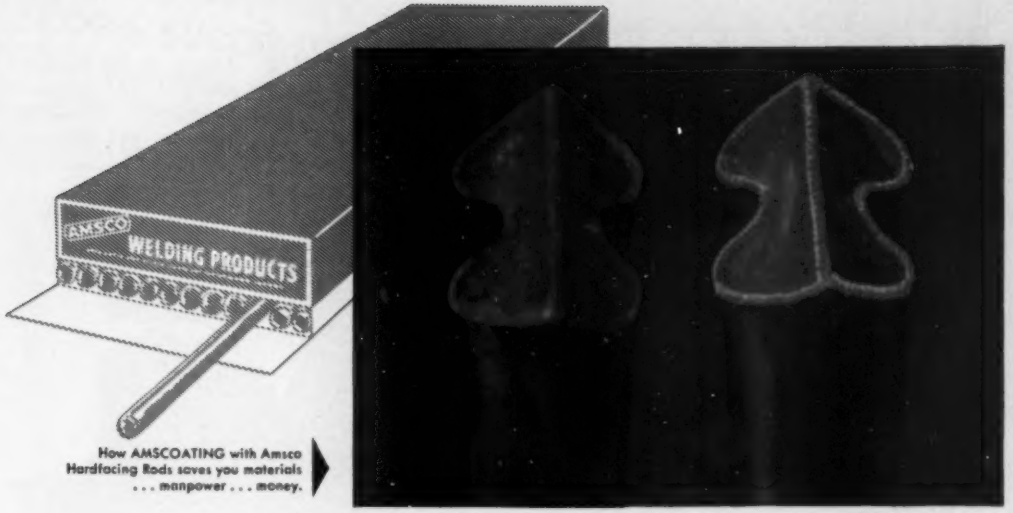
V. C. Allen *(Diesel Truck Haulage Through Inclined Adit,* P. 505) is assistant manager of the Tri-State Zinc Co., Galena, Ill. He has been with the company for the past 24 years. Mr. Allen attended Baker University. He has been an AIME member since 1941.

A. K. Schellinger *(Calorimetric Method for Studying Grinding in a Tumbling Medium,* P. 518; *Technical Note,* P. 523) is an instructor in metallurgy in the school of mineral sciences at Stanford University. He has also been a reader and laboratory assistant at the school, in the department of mining engineering. From 1941 to 1946 he was in Chile as a metallurgical engineer with the Andes Copper Co. Prior to that time he was with American Smelting & Refining in Selby, Calif. He has also done assaying and mining in the Yukon. Mr. Schellinger has an A.B. and an M.S. from Stanford.

J. L. Carne *(Ore Control at Inspiration,* P. 501) has been with the Inspiration Consolidated Copper Co., Inspiration, Ariz., since 1923. He has been a miner, a clerk, an extraction engineer, a tonnage estimator, a ventilation engineer, and office engineer in charge of mine planning. He is now assistant chief mine engineer.

H. H. Cooper, Jr. *(Economic Aspects of Groundwater in Florida,* P. 525) has been a district engineer for the U. S. Geological Survey for the past 5 years. Prior to that time, he spent 8 years as a hydraulic engineer with that branch of the Government. Mr. Cooper was born in Georgia, attended high school in Florida, and took his B.S. in civil engineering from the University of Florida.

S. F. Kelly *(Geophysics Pays Off,* P. 498), a much-sought-out member of the AIME Geophysics Subdivision, has been an active member of his profession since his interest in geophysics was aroused in 1919 through his translation of Conrad Schlumberger's book on geophysical prospecting. Mr. Kelly received his early schooling in New York City, and graduated from the University of Kansas with a B.S. in mining engineering. He was a pilot in World War I, and after the war studied in Paris for 2 years on a fellowship. At this time he became interested in geophysics, joined the Schlumberger organization, and stayed with it for 10 years, as U.S. and Canadian representative and assistant manager of the American branch. In 1930 he established himself as a consultant in geophysics. Since then he has traveled widely in North Africa, France, Newfoundland, Canada, Alaska, and South America. He is now Chairman of the AIME Geophysics Subdivision, and also Chairman of the Geophysics Subdivision of CIMM.



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These bits are used by a Southern quarry for drilling blast holes. A combination of limestone and flint causes extreme abrasion—and a real problem of wear. In an attempt to cut replacement costs, labor and down-time, several makes of hardfacing rods were tried, but without much success.

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Agitating	Mining
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EVERY PARTICLE MIXES

Feed normally enters directly into the standpipe top . . . is sucked down and is positively mixed by the propeller at the lower end. Thus, there can be **no** short circuiting of pulp as every particle is thoroughly agitated and mixed.

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A feed port is available directly to the lower end of the standpipe. Since discharge is at a higher point, an actual gain in elevation can be had for series applications.

EVERY PARTICLE RECIRCULATES

Pulp movement in the tank is constantly toward the adjustable central standpipe due to the sucking and mixing action of the propeller and the resulting controlled vortex down the standpipe. Intermediate recirculation ports may be opened or closed depending on the treatment process.

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Write for Deco Bulletin A2-B2, containing detailed information and pulp density charts for calculating size required.

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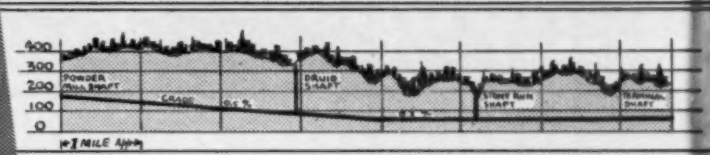
CASE HISTORY OF A SUCCESSFUL TUNNEL JOB

FROM THE EIMCO FILE T190

BALTIMORE TUNNEL



SPECIFICATIONS

Length of this section of tunnel—7 miles.

Size heading—7' (3 miles) 10' (4 miles).

Headings worked—6 — Advance, average 2500' per month, maximum 5000' per month. 32 hole 9' round drilled. 150 to 225 pounds of 40 or 60% powder (depending on rock) per round. Average about 7 pounds per cu. yd. of rock broken. Mucking time average 1 hour, 15 minutes. Mucking machines—Model 40 Eimcos.

The contractor responsible for driving high speed rock tunnels is required to be many things—a competent engineer, a geologist, a mechanic, an expert in labor relations and all of the other skills which the inevitible uncertainty of this work presents.

He must, therefore, be exacting and doubly cautious in his selection of machines. There can be no questions, no uncertainties about the machines doing their jobs, no matter how tough the going.

This is the reason you will find Eimco machines on the big majority of tunnel jobs the world over. There are no uncertainties when you have an Eimco loading out the round. It is fast, safe and low in cost regardless of conditions. You can't beat an Eimco for absolute dependability.

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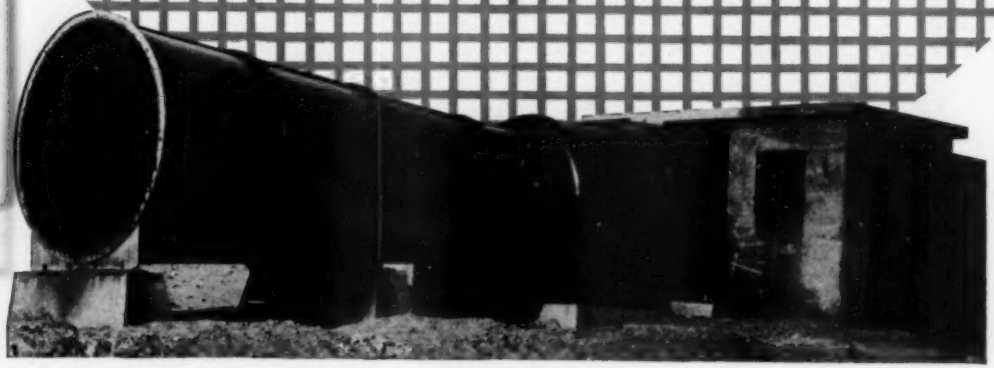


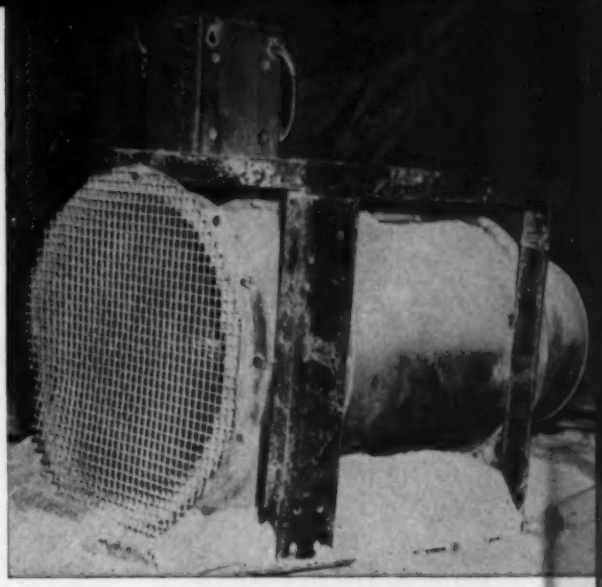
FOR MAIN VENTILATION—

JOY AXIVANE MINE FANS—the only fan with Simultaneously Adjustable Blades.

In the long run, you can count on more air at considerably lower overall cost with a JOY AXIVANE Mine Fan on the job. They're designed for lower speed operation and that means reduced maintenance and depreciation costs, because service life is increased and lubrication is simpler and more foolproof at lower speeds. What's more, you'll cut power costs with JOY's wide range of blade adjustment and simultaneously adjustable blades, giving you the highest possible efficiency over the widest possible operating range and eliminating guesswork settings. ● No matter how your air demand changes, you can always keep a JOY Fan at top efficiency. *Let us survey your ventilation problem—no obligation.*

FOR SECONDARY VENTILATION—

JOY Series 1000 AXIVANE FANS with Standard Adjustable Blades.



For smaller volumes, or where you may need additional capacity in a more or less permanent installation to supplement main ventilation, you'll find JOY Series 1000 AXIVANE Fans ideal. The vaneaxial design was pioneered by JOY in mine ventilation equipment. Series 1000 FANS are compact and space-saving, easy to handle and install, and relatively quiet in operation. They are the only fans in their class with adjustable blades as standard equipment, for your easy maintenance of peak efficiency over a wide range of air supply requirements.

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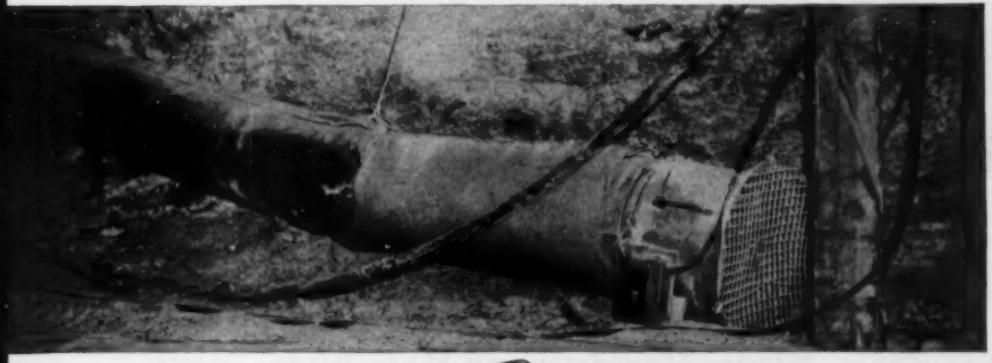
JOY AXIVANE BLOWERS for either low or high pressure duties.

JOY AXIVANE Portable Blowers are all-purpose, two-in-one units. They not only provide smoother air flow and require minimum power, but operate with unmatched efficiency through any length of tubing. You don't need two types of blowers for different sections of the mine—JOY AXIVANE Blowers are suitable for either high or low pressure service. Available in types and sizes to meet every portable air supply requirement, and in electric or air-operated models.



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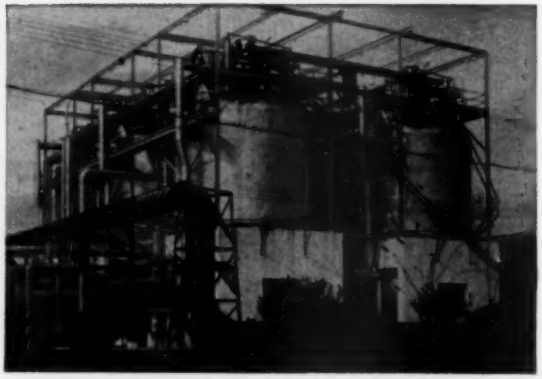
SULPHUR

*Interesting Facts Concerning This Basic Raw Material from the Gulf Coast Region

*SUPERHEATED WATER . . .



Mining operations are most successfully carried out if the water pumped into the sulphur deposit is heated under pressure to a temperature of about 320° F. For large scale mining, enormous quantities of water are required, so, a primary requisite is an adequate supply of suitable water and an efficient power plant in which to heat it.

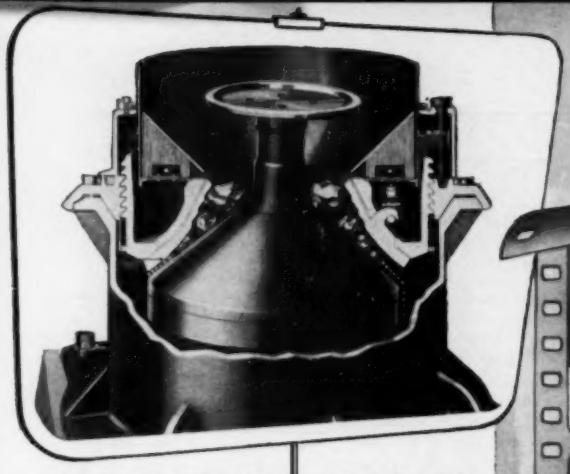
To insure a continuous supply of water at Newgulf, it is the practice to use river water pumped in time of flood or full flow and stored in large reservoirs. This supply is supplemented, when necessary, with well water. Water so obtained is seldom suitable for use in boilers or mine water heaters without being treated first because of natural salts in solution. Softening by chemical treatment is necessary to prevent deposition of scale on boiler tubes and hot water lines.

Loading operations at our Newgulf, Texas' mine

TEXAS GULF SULPHUR CO. INC.

75 East 45th St. New York 17, N. Y.

Mines: Newgulf and Moss Bluff, Texas



"The SYMONS PROCESS of CRUSHING"

as revealed by the camera

'Tis said that "the proof of the pudding is in the eating." The proof in a Crusher, however, is in its ability to continually produce large quantities of desired product economically. That such has been proven by the SYMONS CONE CRUSHER is evidenced by the thousands of Standard and Short Head SYMONS CONES which have been installed throughout the world wherever fine reduction crushing is being done.

The enormous capacity of the SYMONS CONE CRUSHER is made possible by the remarkably simple SYMONS PROCESS OF CRUSHING which is revealed in the accompanying views through the camera's eye. To record the film, a Standard type CONE CRUSHER was sectionalized to expose the crushing cavity.

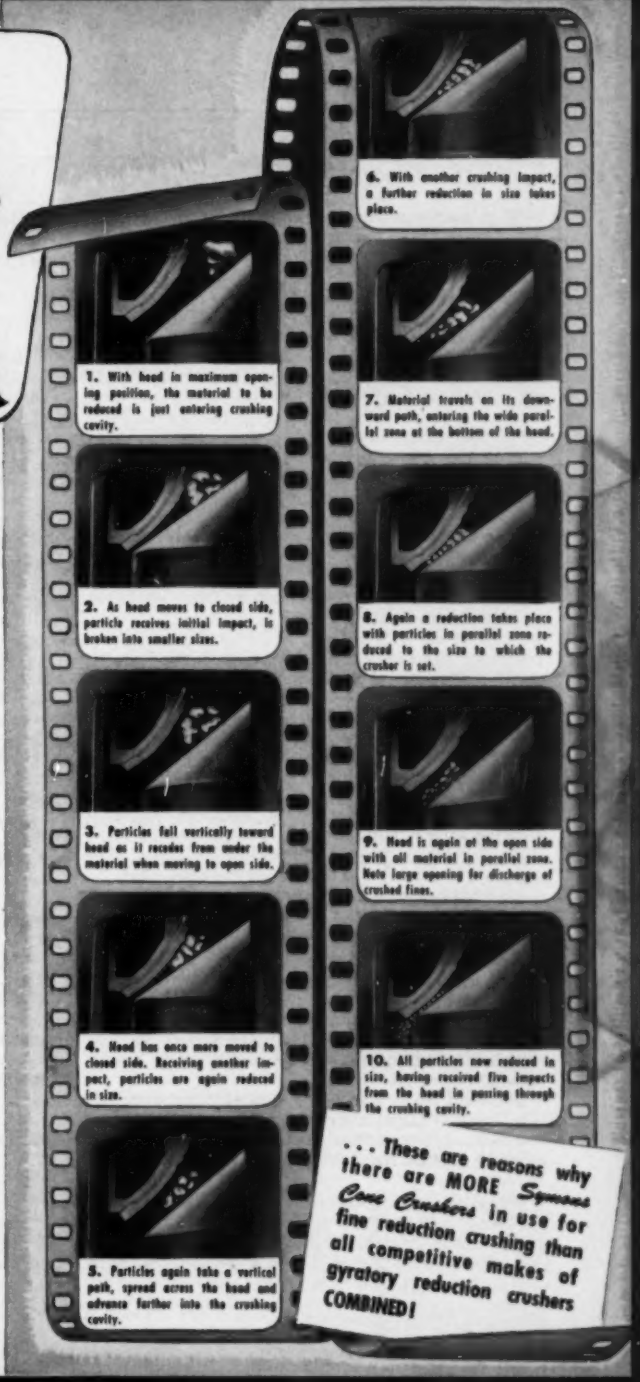
Although the SYMONS CONE is classified as of the "gyratory" type, the principle of crushing differs radically from that of the conventional gyratory since the head or cone in the SYMONS CRUSHER travels at least five times as far and gyrates much faster than in the ordinary gyratory type of crusher.

The material, in its passage through the crushing cavity in the SYMONS CONE, is controlled and timed to receive a series of rapid hammer-like blows before it is discharged.

The crushing action in the SYMONS CONE is a combination of controlled feed, high speed, timing, and extraordinarily large discharge capacity. These factors, coupled with the spring release safety feature of being able to pass uncrushable items—such as tramp iron, etc.—constitute ample proof of the superiority of the SYMONS CONE and the SYMONS PROCESS OF CRUSHING.

The camera reveals that from the time the material enters the crushing cavity until it is discharged, it passes through a successive series of crushing stages with a minimum of abrasion, sliding, or frictional wear—the entire process being one of smashing impact, resulting in maximum reduction.

C151


1. With head in maximum opening position, the material to be reduced is just entering crushing cavity.
2. As head moves to closed side, particle receives initial impact, is broken into smaller sizes.
3. Particles fall vertically toward head as it recedes from under the material when moving to open side.
4. Head has once more moved to closed side. Receiving another impact, particles are again reduced in size.
5. Particles again take a vertical path, spread across the head and advance further into the crushing cavity.
6. With another crushing impact, a further reduction in size takes place.
7. Material travels on its downward path, entering the wide parallel zone at the bottom of the head.
8. Again a reduction takes place with particles in parallel zone reduced to the size to which the crusher is set.
9. Head is again at the open side with all material in parallel zone. Note large opening for discharge of crushed fines.
10. All particles now reduced in size, having received five impacts from the head in passing through the crushing cavity.

. . . These are reasons why there are MORE *Symons Cone Crushers* in use for fine reduction crushing than all competitive makes of gyratory reduction crushers COMBINED!

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Machinery for processing ores and industrial minerals

Trends

A REPORT OF CURRENT ACTIVITY IN THE INDUSTRY

• **With increased coal consumption by the steel industry** assured and an estimated consumption of 108 million tons of coal for industrial power in 1951, market prospects for the industry are bright in spite of losses in the domestic and railroad markets. Statistics show that industrial power consumption of coal doubles every 10 years. If manufacturers are able to deliver the equipment exhibited at the Coal Exposition, Cleveland, Ohio, May 14 to 17, the operators will have little difficulty getting out the coal. Four manufacturers had continuous mining machines on display, some of which were exhibited in more than one model so that there were machines for all commercial thicknesses of coal. The problem of taking the coal away from the machine has been resolved by several types of especially designed conveyors. One of these is cat-mounted at the receiving end for propulsion, with the conveyor following on rubber-tired wheels.

For the first time, Diesel locomotives were exhibited at the Coal Show. J. H. East, Jr., regional director of the U. S. Bureau of Mines, Denver, Colo., expressed the opinion in a paper presented at the meeting that Diesel mine locomotives are the coming means for main-line haulage in many coal mines of the United States. To dilute exhaust gas to a safe atmosphere requires approximately 75 cfm of air per bhp of the engine in addition to normal safe ventilation. He suggested that manufacturers build locomotives to the Bureau specifications and submit them for test as to permissibility. Once this has been established it is believed that organized mine labor will have little objection to their use in underground mining.

Coal augers to recover coal, after strip mining has reached its economic limit, have become accepted throughout the industry, according to D. M. Bondurant, assistant professor of mining engineering, West Virginia University. In support of this statement, these machines were on display in the exhibit halls. Strip operators have also accepted the torque converter for transmitting engine power to rear wheels of trucks, particularly in the new higher horsepower rated engines.

The Coal Show had more exhibits than ever before which is surprising considering the procurement and pricing regulations of the government which make the future market picture uncertain.

• **Monazite sands, from which thorium is extracted,** are being dredged from old gold tailings and placer deposits near Cascade, Idaho, by the firm of Baumhoff and Marshall. The company is using a Yuba dredge #106 with a 6 cu ft bucket. Jigs are used for producing a concentrate sent to the company's plant at Boise for refining.

• **The first Marshall Plan guaranty contract, covering** a European firm's royalty payments for an American firm's manufacturing processes, has been signed with the Gardner-Denver Co. of Quincy, Ill. It is also the first Marshall Plan industrial guaranty granted for an investment in the Federal Republic of Germany, according to the ECA. The German firm is Maschinen Fabrik A. Beien, a coal mining equipment company now making chain conveyors and pneumatic backfill machines. They will begin manufacture and sale of Gardner-Denver mine car loaders for use in German and other coal mines in Western Europe.

• **The Cerro de Pasco Copper Corp. dropped the** word "copper" from its title, effective June 1. The reason: Copper no longer is the major product of the company. Zinc and lead output are now larger than that of the red metal.

• **Nine million dollars, not ninety million as reported** in February (P. 141), will be the cost of the Consolidated Mining & Smelting Co.'s new fertilizer plant at Kimberley, B. C. The plant will produce ammonium phosphate at the rate of 70,000 tons per year, representing a 70 pct increase in ammonium phosphate production and a 12 pct increase in overall fertilizer production.

• **There are signs of renewed activity in Nevada's** Basalt district, just across the line from California's Mono County. The Red Hill Florence Co., formerly active at Goldfield, is said to be considering development of copper properties in the district. The basalt region, once the scene of much mining activity, is said to possess promising deposits of copper and other critical metals. Several copper claims were worked there during World War I.

• **Kennecott Copper has earmarked $7 million for** initial development of its "Deep Ruth" deposit near Ruth, Nev. Operations at the Ruth open pit will continue. The 22½ million ton underground orebody, from which 8000 tons per day of .83 pct copper will be taken, was discovered by churn drilling in 1937, but mining has been uneconomical until the present. It will, however, remain a "high-cost" affair, according to a company official. No government loans or guaranteed "floor prices" on copper are involved, but some arrangements have been made for tax amortization. Mining is scheduled to begin 28 months after the collar on the proposed new main shaft is complete. Total cost of the project may eventually exceed $13 million.

• **A vast new expansion program in the Canadian** aluminum industry will be undertaken by Aluminum Co. of Canada, Ltd., subsidiary of Aluminum, Ltd. A major project in the undeveloped areas 400 miles northeast of Vancouver will supply low-cost electric power for the proposed increase in Canada's aluminum productive capacity. The waters of a chain of lakes will be dropped through a 10-mile tunnel to a powerhouse inside a mountain, 2500 ft below water level in the lakes. An aluminum smelting plant and a new town to house workers will be constructed near the tidewater Indian village of Kitimat. Raw materials will be brought there by sea or via railroad from the Canadian National Railways main line into Prince Rupert. The expected increase in aluminum production is 330 million lb per year.

Trends

• **Mining with mule-power is still hazardous, but** modern equipment is equal to the task. A miner in the Bernice White Ash Coal Co. mine in Pennsylvania was kicked in the lamp battery by a fractious mule recently. The miner went down, but the nylon plastic battery case stood up to the punishment and provided light for the rest of the shift. The aftermath: A mule shoe print remaining on the battery case, and happy officials at the Mine Safety Appliances Co., makers of the battery.

• **The Thirty-Ninth Annual Short Course in Coal** Mining will be held June 4 to July 14 at West Virginia University's School of Mines, Morgantown, W. Va.; Beckley Junior High School, Beckley, W. Va.; and Logan High School, Logan, W. Va. This short course is of special interest to those just entering the industry and seeking fundamental technical knowledge; those seeking to procure foremen's papers, and those with foremen's papers desirous of taking refresher courses.

• **A new aluminum smelting plant capable of supplying** 170 million lb of aluminum annually will be built by Alcoa at Wenatchee, Wash. Construction will begin immediately, with production expected to begin in 15 months. Negotiations with the Bonneville Power Administration and the Public Utility District of Chelan County, Wash. have assured that the necessary electric power will be available.

• **A new type of steel roof prop for anthracite mines** is being tested by the Bureau of Mines in Pennsylvania's anthracite region. German-designed, the "yielding steel prop" consists of two members of approximately equal length, held together near the center by a friction-locking device. As the load comes down on the prop, it collapses slightly before deformation occurs. Props employing similar principles have never been manufactured in the United States, according to the Bureau. The props can be recovered and reused. According to some sources, there is a possibility that an entire pillar line can be taken out, thus making it possible to produce large tonnages of low-cost machine-cut coal, loaded mechanically, and double the life of many existing collieries.

• **The coal industry's competitive struggle will be**come less intense in the coming years, and the point at which coal will permanently replace currently competitive fuels is "just around the corner," according to J. Pursglove, vice-president of Pittsburgh Consolidation Coal. Mr. Pursglove noted that coal represents about 96 pct of recoverable energy reserves, and that oil and gas are being used up at an increasingly faster rate. After 1955, he said, coal will move into "more and more situations occupied by synthetic fuels and natural gases."

• **A $3 million silica refractories manufacturing** plant will be erected by General Refractories Co. near Warren, Ohio. The plant will have the latest screening, grinding, and pressing machinery, as well as scientifically controlled oil-burning kilns, each 600 ft long. Raw materials will come from company-owned properties 18 miles away. This is part of a $12 million expansion program being undertaken by the company.

• **The largest single project in the history of Con**solidated Mining & Smelting of Canada will be the erection of a power plant and dam on the Pend-d'Oreille River at a cost of $30 million. The site will be about 11 miles south of the metallurgical and chemical fertilizer plants at Trail, B. C. Stone and Webster will design and build the project, which is scheduled for completion at the end of 1953. The company now has $62 million invested in development projects: $12 million for modernization of the lead smelter at Trail; $9 million for the ammonium phosphate fertilizer plant at Kimberley; over $3 million for enlargement of the Trail zinc plant; nearly $3 million for the Kootenay River to Kimberley power line; and over $5 million for preparation of the Bluebell and H.B. mines for production.

• **Pierce Management, Inc., Scranton, Pa. will ad**vise the Greek government for the next 3 years on their Ptolemais lignite project. This involves open-pit mining of 3 million tons of lignite per year, manufacture of 600,000 tons of briquettes a year, and building of a 40,000 kw power station costing $18 million. Headquarters for Pierce personnel have been established in Athens.

• **The Leadville tunnel, being drilled to unseal Colo**rado's rich manganese, lead and zinc mines, encountered ore at 8573 ft, some of which assayed $241.78 per ton. Samples from a bedding contact between the Sawatch quartzite and overlying Peerless shale assayed from 90 to 200 oz of silver per ton, and more than 50 pct lead. They also contained 3 pct zinc, 1.9 pct copper, and 0.09 oz gold. Tunnel drivers are carrying on with the tunnel, and at last reports had reached the 8700-ft mark.

• **A new phosphate chemical plant that will recover** uranium as a by-product will be built by the International Minerals and Chemical Corp. The initial objective will be to produce defluorinated phosphate for the animal feed manufacturing industry and multiple superphosphate for the chemical fertilizer industry. The recovery of uranium compounds will be an additional step in these processes, according to Louis Ware, company president. The new plant, to be located adjacent to International's phosphate mining property near Mulberry, in Polk County, will make 100,000 tons of defluorinated phosphate per year.

• **Freight car shortages during 1951 will be worse** than those experienced in World War II and in the post-war period, according to Defense Transport Administrator Knudson. Both the coal and iron industries will feel the pinch unless 300,000 new freight cars are built and put into operation. Steel allocations for 10,000 freight cars a month fell 50 pct short of expectations in January and they were 30 pct below that objective in March. It is hoped that the Controlled Materials Plan will ease the situation.

Triple-alloy steels containing nickel offer designers the following *triple* advantages:

1. OUTSTANDING PERFORMANCE—Strength and toughness, resistance to wear, fatigue or shock to meet a wide range of requirements, as dictated by design.
2. RELIABILITY—based on consistently uniform response to heat treatment.
3. ECONOMY—resulting from standard compositions precisely graded to match the engineers' needs.

Service records established by triple-alloy steels over a period of years show that they are giving excellent results in many diverse and exacting applications.

The many standard combinations available permit accurate and economic selection for specific uses.

Because of their many advantages, these triple-alloy steels warrant your careful consideration when planning new or improved designs. We shall be glad to furnish counsel and data upon request.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.

M. A. Hanna is investigating a nickel prospect near Riddle, Ore. Drilling is under way and a prospect shaft is being put down to obtain samples for metallurgical test work. The deposit is favorably situated for open pit mining. The property had been drilled previously by the USGS and by Freeport Sulphur Co.

A $75,000 laboratory pilot plant will begin operations this year to determine if economic beneficiation of a deposit of low grade iron ore, being examined by M. A. Hanna in the Iron River, Mich., district, is possible. Three miles east of Randville 2560 acres of land have been acquired, and drilled, over the last 2 years. The ore is reported to be 34 pct Fe.

Construction of the Oliver Iron Mining Co.'s pilot taconite beneficiation plant at Mountain Iron, Minn., began on May 17 with the turning of a spadeful of earth by Oliver's president R. T. Elstad. It is expected to be put in operation by the summer of 1952. It will be a year-round operation, producing 5000,000 tons of concentrates annually from 2 million tons of taconite rock.

Construction work has begun on Tennessee Coal, Iron & Railroad's new ore handling terminal at Mobile, Ala. It will serve as a transfer point for 2,500,000 tons a year of high grade ore to be imported by TCI from U. S. Steel's Cerro Bolivar operation in Venezuela. Knappen-Tippetts-Abbett Engineering Co. of New York has been awarded the engineering contract.

Significant new uranium production has been predicted for the Colorado plateau areas of eastern Utah, northern Arizona, and New Mexico. Uranium has also been found in Colorado, Wyoming, Montana, Idaho, and Florida, according to Phillip D. Merritt, of The Atomic Energy Commission's raw materials division.

Plans are being formulated for the construction of a manganese plant near El Paso, Texas. Minas Consolidadas S.A., which owns manganese mines in Mexico, is being joined by Denver Equipment Co. and the International Mining Co. of New York in the project. The plant will produce 70,000 tons of concentrates a year.

Sherritt-Gordon is spending $28,318,000 to develop a nickel-copper property in northern Manitoba, Canada. When completed in 1954 the property will produce 17 million lb of nickel, 9 million lb of copper, 300,000 lb of cobalt, and 70,000 tons of ammonium sulphate fertilizer. The program includes a $17½ million dollar refinery in Alberta, at a location not yet chosen.

The General Services Administration will support the price of tungsten at a base price of $63 per short ton unit of contained tungsten trioxide for the next five years. In addition, DMA will aid in the establishment of milling facilities in tungsten-producing areas where such facilities are justified but do not now exist.

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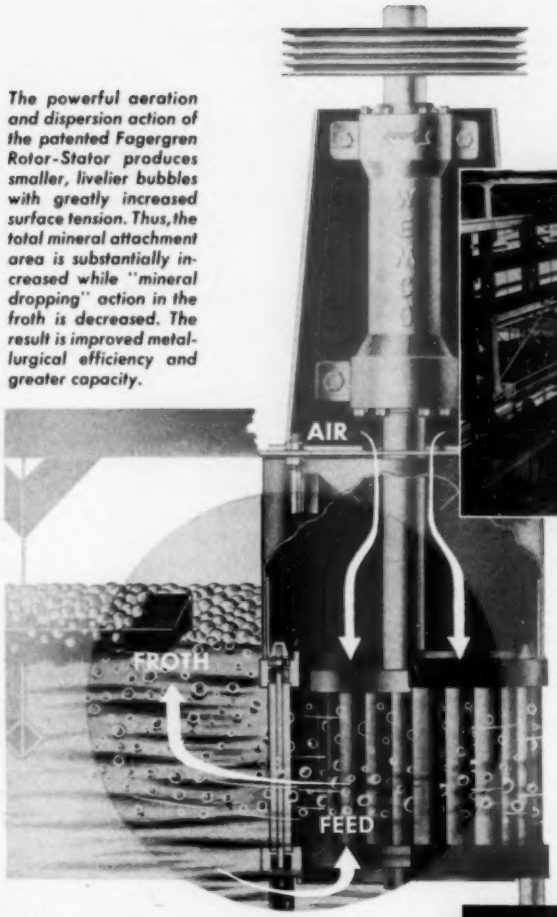

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EDITORIAL

HIRING — SCIENCE OR GUESSWORK?

THE class of '51 will emerge from the colleges this month, and mining companies will begin selecting the graduates who are seeking a place in the industry. Since a mining operation is only as good as the men who run it, this is a good time to start reviewing personnel policies. Haphazard methods lead, of course, to unsatisfactory results, and they can also result in loss, inasmuch as engineering talent always represents a financial investment, and replacement entails further expense.

The work performed by engineers will fall under one of five broad classifications—operations, engineering, sales, teaching, or research. Certain innate tendencies and personality characteristics equip individuals to undertake one or more of these types of work. Mine operations are, for instance, often better handled by the extrovert personality who enjoys organizing men and equipment into a workable team than by the person who prefers the realm of mathematics and engineering instruments. Educational training may be the same for all, but personality factors play a part that demands the attention of a trained interviewer. The hopes, fears, and basic interests of applicants seldom appear on employment questionnaires, but they all determine the type of work an employee will do.

Science has come to the aid of employers with psychological testing to determine the fitness of men for given tasks. This technique, combined with careful interviewing, has been well received by all types of industries and has been instrumental in placing job applicants where they will be most effective. It must be remembered that interviewing is not a task for the amateur, but rather a job for those trained to evaluate carefully all the factors determining individual attitudes and capabilities. No single factor, such as educational background, or personality alone, is assigned more weight than any other factor by a trained interviewer. All are given equal consideration. This, then, is a form of human engineering, embodying principles of the type that enable engineers to work efficiently with the tools they have at hand. The requirements are the same in both cases: a knowledge of the tools, and a clear idea of the job to be done.

Because the mining industry tends toward decentralization, interviews are often neglected in favor of mail-order hiring. The price paid for this failure to use a basic tool of management can include both the cost of training the wrong man for the job, and the inefficiency resulting from labor turnover. Large mining companies are in a position to choose carefully by sending interviewers across the country to screen the crop of new graduates, and smaller companies can go to local colleges or avail themselves of the services of professional interviewers located near the homes of applicants. Given a detailed job specification, the interviewing organization can forward recommendations to potential employers.

A hiring policy that is obviously an intelligent one establishes an immediate feeling of employee confidence. For employers, the results of human engineering are obvious: sound hiring policies attract more and better applicants, possible misfits can be eliminated before entering the organization, and money is not wasted in fruitless training of the unqualified.

Engineering, then, is not confined to mines and mills. It can and should begin in the personnel office.

Abashchevo—2 coal mine at Kuznetskugol, the result of one of Russia's postwar Five-Year Plans.

Sovfoto

RUSSIA'S MINERAL POTENTIAL

by PAUL M. TYLER

MILITARY power stems from industrial power and industrial power in turn depends predominantly upon an ample and assured supply of mineral raw materials. It thus becomes the duty of mineral economists to collate the vast array of data and logical deductions in order to reach an unemotional judgment as to the ability of the Soviet economy to withstand the strain of prolonged military action on the modern scale. Russian publications, reports, and official speeches have been laboriously screened and analyzed. Since these are the sources of information for the lower echelons of the Soviet industrial organization itself, they carry factual data that can be pieced together to show the present-day pattern. Apparent contradictions and obvious distortions or omissions can often be rationalized on the basis of observations made by foreign engineers and consultants during the 1930's and by checking against the technical literature published before even so-called technical articles were riddled by bombastic and presumptuous claims.

Soviet reports naturally tend to over-estimate tonnages and to include geologically inferred ore as measured reserves. Such exaggerations should be expected where the hundreds of prospecting parties are directed to find ore or else be sent to slave labor camps. Competent geologists, engineers, and metallurgists were liquidated along with other professional men in the purges of the 1930's and a similar fate may await those who might venture to write a pessimistic report. Although in view of such pressure, Soviet reports often must be discounted, they need not be discredited. They usually reveal a clear concept of the genesis and geological environment of the deposit and show evidence of careful field work. Moreover, the normal economic yardsticks are too inflexible to employ under the Soviet central management. Provided the recoverable mineral is urgently needed, low grade of the ore, poor accessibility, mining and treatment difficulties or high costs may be no barrier to exploitation. No private company could undertake the vast exploration now in progress in some of the oil fields between the Volga and the Urals where the yield per well is bound to be small. The miserable quality of coal from the Kizel field, the Korkimo brown coal operations, and the meager returns from innumerable lean gold placers and base metal lode mines further illustrate the contrast between standards in the USSR and in the United States.

Slave labor is another factor. No one knows how many captives of the NKVD (Secret Police) are still alive. The number is probably between 8 and 15 million as there are 41 forced labor camps employing an average of 250,000 convicts. The death rate in most of the camps for mine workers is appalling. The worst, probably, is in the Kolyma gold field where 40 pct of the workers succumb each year to Arctic exposure, disease and brutality. In these camps the workers are fed in proportion to how much work they perform and quotas are set so high that few can earn enough to keep up their strength. As they grow weaker they become less and less able to meet their quotas and eventually are starved.

However skeptical one may feel about the trustworthiness of Soviet geological reporting, it must be recognized that an 8.4 million sq mi land mass is under consideration. Including satellite countries, the Soviet sphere of influence extends over 13 million sq mi which is greater than the area of the entire British Commonwealth and compares with 3.6 million miles possessed by the United States. Enough is known of the geology of this vast area to enable some evaluation of official claims of ex-

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ploration achievements. As to production claims the method of presenting statistical statements in percentage changes or percentage fulfillment of an annual production plan is deliberately confusing. With some diligence, however, clues can be found for translating these relatives into absolute figures. Unfortunately, different analysts sometimes come out with different figures but in respect to coal, iron and steel, and certain other basic commodities, there is wide agreement. Soviet statistics apparently are not deliberately falsified.

Economic Self-Sufficiency?

The USSR is undoubtedly the world's largest producer of manganese and probably of magnesium and mineral fertilizers. It ranks second in production of aluminum, asbestos, coal, gold, iron and steel, and oil and it is probably near the top of the list of world producers of chromium, copper, lead, platinum, silver, and zinc. Available data indicate an excess of consumption over Russian production of some two dozen minerals. Indicated shortages of antimony, molybdenum, tungsten, perhaps tin and certainly uranium are real, but mineral imports are derived almost entirely from Soviet-dominated countries. The Russian orbit is designed so as to withdraw if necessary from all trade with democratic nations. In fact, this orbit is now virtually self-contained. In many cases, however, mineral self-sufficiency places a heavy strain on limited railroad facilities and is wasteful of badly-needed equipment and manpower. Not only are some of the deposits poorly situated in respect to major consuming centers but the ores themselves are quite low grade. An increasingly large percentage of supplies of a dozen minerals comes from deposits north of the Arctic Circle.

Although Russia is still largely an agrarian country, its industrial progress under the several Five Year Plans has been impressive. As reported by the United Nations (*Monthly Bulletin of Statistics*. Dec. 1950, P. 4), production during the third quarter of 1950 showed the following gains over the corresponding quarter of 1947: All industries 79 pct higher, pig iron 62 pct, steel ingots 81 pct, copper 63 pct, lead 60 pct, zinc 115 pct, coal 44 pct, crude petroleum 41 pct, commercial fertilizers 139 pct, and metallurgical equipment 160 pct. Absolute figures as estimated for 1937 and 1950 and shown for leading mineral products in Table I testify further to the great strides that were made during and after the second World War. Comparisons based upon conditions under the Czarist regime show gains that are almost fantastic when expressed in percentages.

Table I. Estimated Production of Specified Minerals in the USSR in 1937 and 1950

	Thousands of Metric Tons	
	1937	1950
Coal	120,000	250,000
Petroleum	20,000	37,000
Iron ore	27,770	40,000
Pig iron	14,450	19,500
Steel ingots	17,730	25,400
Rolled steel	13,000	17,800
Manganese ore	2,752	3,700
Chromite	187	800
Tungsten ore	0.8	9.4
Molybdenite	0.05	3.4
Vanadium	0.15	0.65
Aluminum	38	180
Antimony	0.5	3
Copper	98	250
Gold	0.17	0.23
Lead	62	105
Magnesium	0.5	10
Nickel	2.5	25
Tin	0.5	9.0
Zinc	78	123
Asbestos	86	220
Cement	6,000	9,000
Magnesite	0.9	1.2
Salt	4,000	7,000

Reasoning from the record of rapid expansion of Soviet industry, many observers fear that Russian numbers plus German technical know-how can soon create a Frankenstein that will destroy the world. The record shows that Hitler's highly mechanized battalions were overwhelmed by never-ending columns of Russian infantry just as United Nations forces in Korea were driven back by swarms of ill-equipped Chinese. The facts do not justify a complacent attitude. On the other hand, the Soviet economy has shortcomings and its rate of growth from small beginnings is not the measure of its present-day industrial power. The level of industrial output in the Soviet Union is still low by modern standards. The peasants have failed to attain the comforts and simple luxuries promised them after World War II as the increased production has been confined almost entirely to capital goods. Although the area is almost 2½ times as great and the population is 37 pct greater than that of the United States, the number of industrial and office workers in Russia is nearly 20 pct less and the average output per worker is much less. In 1937, labor productivity was only 45 pct of the United States level in the Soviet iron and steel industry and in most other industries it was only 20 to 25 pct as high. Based upon 1949 figures, the tonnage of coal produced in the Soviet Union had risen to barely 55 pct of American production whereas in almost every other mining industry the comparison was far less favorable. Typical ratios were, 35 pct for steel, 32 pct for copper, 22 pct for electric power. Despite the great numbers of workers on farms, the Russians make rather a poor showing even in agriculture. The total output of grain, for example, is only about 80 pct of the American output and it may be questioned whether the USSR can grow enough food for its increasing population as more and more workers are shifted from farms to factories, mines, and military service.

Oil Supplies

Oil supplies are undoubtedly scarce. Russia has ranked as a leading producer of petroleum since 1863 and used to employ it freely under steam boilers of locomotives, Volga River boats, and power plants and for space heating. Late in 1949, however, orders were issued to convert oil-burning equipment to coal and every effort is now being made to expand production and to develop new sources. Russia's output is barely 10 pct of that of the United States and the 2 or 3 million additional metric tons that might be squeezed from Balkan satellites is only a drop in the bucket. However, only a small fraction of Russian oil has to be channeled to civilian uses and the current total supply is more than three times as much as Hitler's Germany ever had during World War II and more than one half as much as the maximum used by the armed forces of the United States. Seizure of the

rich oil fields of Iran and Iraq would double the Soviet supply and so provide enough for the Kremlin's needs for all-out warfare.

This oil shortage is not occasioned by lack of resources. Although the USSR is generally credited with only 9 pct of the world's proven reserves, its potential resources are great. The major portions of the Middle East and Arctic petroleum provinces are both within its borders. The aggregate area characterized by oil and gas seepages is enormous. Most of the 25,000 producing wells at present yield only a dribble of oil after years of pumping but other fields flank the Caucasus Mountains and still others are on the west slopes of the Urals in a northward trending zone that stretches 1500 miles from the depleted Caspian area to the shores of the Arctic Ocean. Promising oil regions in Asiatic Russia include areas in western Turkestan not far from the Caspian; the Azbek and Tadzhik districts in southern Turkestan near the Afghan border; and the Fergana district in the republics of Uzbek and Kirghiz near the borders of western China. Some production has come from all these regions and there are other promising regions in presently inaccessible areas east of the Urals at the mouths of the Lena and Yenesei Rivers along the shores of the Arctic Ocean; in the great bend of the Lena; near the Mongolian border at Lake Baikal; above the Manchurian frontier; and on Sakhalin Island.

Exploitation of these widely distributed reserves has been delayed by lack of equipment and know-how. For many decades, drilling was restricted to shallow depths but recently wells have been sunk to a depth of over 2000 meters and there is talk of drilling to 3000 meters. Although the present writer has no positive information regarding pipe lines, railroad tank cars, or ocean tankers, he believes transportation facilities from the productive oil fields to the Pacific Coast are inadequate to maintain supplies of fuel for mobile equipment during a prolonged Asiatic military effort, even if they were available in Europe.

Soviet propaganda places tremendous emphasis upon the geographic shift of industry and the development of new industrial centers and supporting bases, for industrialization throughout the country. The principal expansion, however, was in the Urals after the Germans invaded the Ukraine and also the much overrated "gigantic economic complex" founded upon the exchange of Ural iron ore and Kuznetsk coal. Magnitogorsk and Stalingrad, the new metallurgical centers, are 1200 miles apart. In fact, all the four great industrial regions are widely separated. In addition to the aforementioned newer areas just behind the Urals and in the Kuznetsk basin there is the Moscow-Leningrad area in northwestern Russia and the highly developed region comprising the Donetz coal fields in the Ukraine. There are scattered mines, slave labor camps, and military bases across the great expanse of Asiatic Russia with some concentration near the Pacific. Notwithstanding a few new mining districts that have been opened up within the last decade, the geographic pattern of the Russian economy has changed much less rapidly than is generally supposed. Current expansion is taking place principally in the older industrial regions in European Russia. The ideals expressed in the writings of Marx, Engels, Lenin, and Stalin himself are still loudly acclaimed but the plain fact is that efforts to develop a better balance between town and country and to foster the cultural and economic development of backward republics have been postponed. In Russia, as in the capitalist countries, the settlement and industrialization of underdeveloped areas is likely henceforth to be spearheaded by mining industries.

Coal and Iron

Industries are naturally attracted to coal fields. Russia has abundant coal resources and so far she has managed to keep production in step with the rapidly expanding demand. Reserves in sight and probable, as reported by M. M. Prigorsky in 1937, are upwards of 1.6 trillion tons, about 20 pct of the world total as commonly computed. About 10 pct of this is Carboniferous in age, 57 pct is Permian, 23 pct Jurassic-Triassic, and 10 pct Tertiary (lignite). The best coking coal, low in ash and sulphur, is in the Kuznetsk Basin. In the Donetz Basin, the heart of the industrial development of the Ukraine, the coal averages about 3 pct sulphur most of which is chemically combined and so cannot be eliminated by washing. Coking coal is mined to some extent also in the Karaganda, Kiezel, Pechora, Tkvareheli, and Tkvibuli fields. The new Vorkuta field yields coal with as little as 0.7 pct sulphur but with 8 to 15 pct ash. The Kiezel coal in the Urals is poor, carrying 24 pct ash and 2 to 3.5 pct sulphur, and the Karaganda coal is also high in ash. New coal mines, some of them strip mines, have been opened in Bureya (Khabarovsk territory), Ekibastuz (Kazakh), Kuyargas (Bashkiv) and Uzgen (Kirghiz). Pechora is reserved largely for supplying the Leningrad region and Moscow continues to get its fuel from Tula.

Steel has been called the symbol of Russia's rise to military power. The iron ore resources of the Soviet Union are relatively more abundant than even the coal resources, possibly greater than those of any other country. It is true that only 5 pct of the iron resources are east of the 63rd Parallel and all but 9 pct of the coking coal lies west of that line. It is also true, as almost every writer on the Soviet industry has pointed out, that it is a long rail haul for coal from the Kuznetsk Basin to the Ural mills and that the steel mills of central Russia must transport ores from the Ukraine in the south and bring coking coal from the Vorkuta which lies north of the Arctic Circle. Actually, however, 75 pct of present-day steelmaking capacity is in two regions, the eastern Ukraine and the trans-Ural area, where ore, coal, and markets for the products are all favorably disposed geographically.

Notwithstanding the much-dramatized aims to decentralize industry and especially steel productive capacity, 70 pct of the population of the Soviet Union and probably at least as large a segment of its industrial power is concentrated in the rather narrow belt in European Russia extending from the Caspian Sea to Leningrad. In the vast areas east of the Urals, the only important steel mill is at Stalinsk in the Kuznetsk Basin which still depends in large measure upon ore supplies from Magnitogorsk which have to be carried by an overburdened railway system. Further eastward to the Pacific there is a steel mill of 200,000 tons annual capacity at Komsomol'sk and a smaller plant in Transbaikal. Geological conditions are deemed unfavorable for finding large new sources of iron ore in Asiatic Russia.

Within the space of this relatively short study it

is impossible even to list the tens of thousands of mines and prospects. Those who do study such data, however, are likely to reach the conclusion that the Soviet Union has the necessary geological endowment and that its ruthless determination to meet the requirements of its military machine has already made it one of the leading mineral-producing nations. Present-day limits on expanding production are imposed by available plant and equipment or by management problems rather than by any deficiency of reserves in the ground. On paper, at least, the Soviet economy has become self-sufficient at its present level with only a minimum of help from bordering countries, most of which have already been enslaved by Moscow. No major breakdown in mineral raw material supplies at current or even at substantially higher levels is likely to occur except by reason of collapse of human resources, transportation failures, or unforeseen circumstances such as sabotage or war damage.

Military Considerations

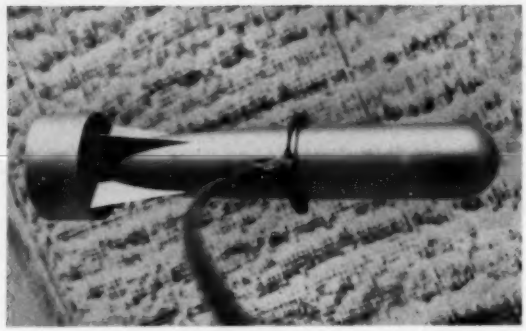
Since the grandiose aims of the several Five Year Plans have so nearly approached accomplishment in so many cases, the main question is whether these plans would provide enough tonnage to implement sustained military aggression at high tempo over a period of years. Stockpiles of mineral products can scarcely have been built up to large proportions and when they are used up the Soviet Union would be dependent upon current production within its then existing sphere of influence. The answer to this question of course would depend upon the nature of the conflict—whether by land or sea or air—and other factors that the present writer is not competent to predict. However, those who have had experience in mineral affairs in two world wars cannot readily believe that the slide rule boys in the Kremlin can foresee each and every eventuality. Almost as soon as the previous great wars broke out virtually every prepared schedule of mineral requirements had to be revised or scrapped. The pattern of mineral demand is likely to change overnight as new weapons are taken out of wraps or when action shifts to a new theatre. Strategic bombing and other enemy actions may impair transportation facilities or destroy the sources of supply.

Russia's mineral supply sources are still so highly localized as to be vulnerable to air attack or sabotage. The already inadequate supplies of oil are largely confined to the shores of the Caspian Sea. Copper production would be dangerously reduced by damage to the principal refinery near Sverdlovsk or to the Kounrad mine and smelter. The Ridder mine, one of the world's great mines, is the predominant source of lead and zinc. As previously noted, the great bulk of iron and steel output is almost equally divided between the Donetz Basin and the Urals plus the recently developed outpost in the Kuznetz Basin. Although new rail lines have been built to Pacific ports their only link with major steel mills and industrial centers is the Trans-Siberian Railway. The airline distance from Vladivostok to Stalinsk is over 2000 miles and the Ukraine industrial region is 5000 miles away. For at least 1500 miles of this distance, including the seemingly vulnerable loop around Lake Baikal, there are no branch railroads that could carry the traffic if the main line were cut.

Many writers have cited the amazing willingness of the Russian people to endure hardship as an asset because it has made possible the employment of almost all resources for war needs. This view misses the fact that a people that has always been on near-starvation rations cannot long survive an enforced reduction in their present low standard of living. They cannot live on their fat when they have no fat. The writer feels that the low standard of living of Russian peasants is a fundamental weakness for the reason that it affords no emergency reserve. There is no reservoir of civilian consumption to divert to additional military needs. Notwithstanding its larger population, the Soviet Union's real national income is scarcely more than one third as large as that of the United States. It follows that every ruble's worth of armament represents a much more burdensome levy on the national product and that the USSR cannot possibly match the United States in military preparedness if the U. S. is willing to make the necessary reductions in its accustomed standards of living. The Soviet program of industrialization has enhanced measurably the defensive strength of the country as proved by comparing the invasions of Napoleon and Hitler. On the other hand, it does not seem to have provided the materials for waging a major intercontinental offensive over a period of years unless augmented by control over additional facilities for producing and processing strategic mineral raw materials.

The Anshan-Penshihn area south of Mukden in Manchuria has several billion tons of iron ore, 700 million tons of coking coal, abundant magnesite and other refractories, and ferroalloy and graphite resources. Its rated pig iron capacity, however, does not exceed 2.5 million tons a year. Another 5 million tons of iron and steel are produced in Eastern European satellites but these countries have to import most of their ore from Scandinavia and are deficient in virtually all ferroalloys. If Russia could capture the Ruhr industrial area and continue to operate the German steelworks, its steel potential as well as its munitions manufacturing capacity would be doubled. Statistically, however, it can be shown that possession of all the ingot steelmaking capacity of Western Europe would still leave the Soviet Union with only two thirds as much as now exists in the United States. Full-scale operation of Europe's blast furnaces and associated steelworks, moreover, presupposes free access to high grade ores from Sweden, Norway, and other sources which would involve the maintenance of fairly long ocean-shipping lines, as well as protection of mines, railways, canals, and docks.

In conclusion, it should be mentioned that historically and currently the Russian people have had less experience than Americans or even western Europeans in handling mechanical devices and in building and operating industrial plants. Significant, too, is the stifling effect of their industrial system upon the resourcefulness of Soviet engineers. Individual initiative is discouraged below the top levels of command where decisions are made for political rather than technologic or economic reasons, often without intimate knowledge of on-the-spot conditions. It follows that the flow of minerals to Soviet industrial and military efforts will depend more upon intangible factors than upon known resources in the ground or even upon the nominal capacity of available facilities for getting them out.



GEOPHYSICS PAYS OFF

Twenty five years of exploration has shown that the "geophysical dollar" is worth $1780 in the Orange Free State, $1488 on the Witwatersrand, $85 in Sweden, $28,000 in the Transvaal and $3500 or more in the U.S.

by SHERWIN F. KELLY

GEOLOGISTS are not required to justify their profession by proving that they can discover ore more economically than by ignoring geology, nor must a diamond drilling contractor justify the footage costs of his holes. For over 25 years, geophysical exploration has been applied on an expanding scale in the search for mineral resources, and anyone who is today unconvinced that geophysical techniques can play an important role in an exploration program, will probably remain unconvinced.

Note the expression, "play an important role in an exploration program," a statement phrased to avoid instigating acrimonious discussions as to whether orebodies are discovered by geophysicists or by geologists or by drillers. Since the inception of modern geophysical techniques about 1921, an adequate exploration program has required the complete integration of geology, geophysics and drilling. The question is not whether geophysics discovers ore, but whether or not geophysics can justify its inclusion in an exploration program.

For the purpose of presenting the case for geophysics it will be necessary to abstract the geophysical phases of many exploration programs from their proper setting in the geological-geophysical-drilling framework. This may bring forth the accusation that geophysicists are attempting to claim exclusive credit for the discovery of these ore deposits. But what is meant by "discoveries?" Geologists have been heard to excoriate geophysicists for claiming credit for the discovery of important orebodies (some of which, incidentally, geologists and drillers had spent many futile years in fruitless hunting), on the grounds that geophysicists had discovered *nothing* but a few anomalies, and that it was the drills that discovered the ore. But of course this interpretation also precludes a geologist ever taking credit for the discovery of an orebody; only the drills can do that!

The discovery of iron ores by magnetic methods dates back to the 17th century, but any attempt to evaluate the early work by those unnamed geophysicists would be a herculean, if not an impossible task. The data will be limited to the period subsequent to World War I, with the inclusion of a few discoveries immediately prior to that event. What is offered below is far from complete. They will provide only some outstanding highlights of more important discoveries. It is to be hoped that additional data will be forthcoming which will permit the compiling, in tabulated form, of a far more extensive roster of discoveries in which geophysics has played an important part.

The earliest discoveries in the modern period of electrical prospecting apparently date from 1913. One of these is the discovery of a lens of pyrite at the Sain Bel pyrite mines in France. Experimental work on this property by Conrad Schlumberger in 1913 revealed a center of spontaneous polarization activity which, in 1920, was investigated by underground workings and proven to be due to a small lens of high quality pyrite. Another discovery, also about 1913, was that of the copper orebody at Tilva Roch, near Bor in Serbia, as a result of an electrical survey for the Bor Mines by Schlumberger and his associates.

Experiments in electrical prospecting were conducted in Sweden at this same period, but information at hand lists discoveries by electric or magnetic methods only since 1918. This information from Sweden has kindly been furnished by Per Geijer, director of the Geological Survey of Sweden, by Helmer Hedstrom of AB Elektrisk Malmletning and by the Boliden Mining Co.

In calculating the values and expenditures below, the figure of 4 Kronor to the dollar is used, having been suggested by Per Geijer as a good average value for the time under discussion. Copper is cal-

MR. KELLY is Chairman, Geophysics Subdivision, AIME, and Chairman, Geophysics Committee, CIMM.

culated at 12c per lb., lead at 8¼c per lb., zinc at 9¼c per lb. and silver at 44.75c per oz.

A geological publication in Sweden recently estimated that some 100 sulphide orebodies have been found in that country by geo-electric work since 1918. On only a few of these are data available as to the costs of the geophysical work and the value of the ore subsequently discovered. Among these are listed four zinc-lead orebodies which have been discovered in central Sweden in the last few years as a result of magnetic and electrical surveys. The cost of these geophysical surveys is estimated to total about 60,000 kronor, or $15,000. At least three of the bodies are commercially workable, but to date the estimates of reserves are available for only one of them. These reserves total 10,000 tons of lead, 15,000 tons of zinc and 12 tons of silver which at about the lowest prices prevailing during or since World War II (given above) would be worth over $4,500,000. Briefly, an expenditure of $15,000 for geophysical work played an important role in discovering three hundred times that value in metallic ores, in only one out of three exploitable bodies thus discovered.

Some recent magnetic discoveries are also reported, again numbering four. These, too, lie in central Sweden and were made between 1932 and 1947. Lumping the four together, the geophysical work cost a total of about $12,000. The iron ores discovered on the basis of this magnetic work have been estimated to value approximately $70 million, and this figure omits one orebody whose value has not been estimated, but is probably of the order of $5 million. Letting the value figure stand at $70 million, the ratio of the value of the ore discovered to the cost of the geophysical work is of the order of 5800 to 1.

The most complete data come from the Boliden Mining Co., which lists 11 deposits which have been, are being, or shortly will be exploited, and which have been discovered primarily as a result of electrical surveys, occasionally supplemented by magnetic and gravitational work. These discoveries date from 1918 to 1940. From 1918 to 1949 the company estimates that the total expenditure for geophysical exploration was 5,300,000 kronor, or approximately $1,300,000. The Boliden mine alone has produced gold valued at $92,000,000. The combined production of the 11 deposits by the end of 1949 was 192 tons of copper, 77,000 tons of zinc, 96,000 kg of gold, 380,000 kg of silver, in addition to pyrite and some arsenic and nickel. Considering only the copper, zinc, gold and silver, the value of this production to date is $118 million. Furthermore, the remaining ore reserves are estimated to be at least as large as what has been mined up to now. Doubling the above figure then gives a total value for these 11 deposits of $236 million. The ratio of return in this case is 180 to 1.

If the foregoing figures are combined, $1,327,000 was spent for geophysical work to discover orebodies worth $192 million. This yields an over-all ratio of $145 to $1. Obviously, other geophysical work must have been carried out over barren ground, and therefore yielded either no geophysical indications, or indications which later proved to be deposits of no commercial value. The task of putting a value on geophysical surveys which serve to eliminate barren ground is outside the scope of this present paper. The most that can be done with it is to include the cost thereof in the total figures, and charge such costs against other discoveries. On this basis, the above estimate of geophysical expenditures must be increased substantially. An approximation has been furnished which puts the total cost of geophysical work in the search for metalliferous ores in Sweden since 1918, at about $2,250,000. Comparing this total expenditure with the total values discovered, the ratio is $85 returned for every $1 expended in geophysical work.

A few comments on the above items may prove of interest. Of the four iron orebodies discovered, three were deep-seated, their apices lying 100 meters or more below the surface. The fourth proved to be a large body of magnetic iron ore lying below a smaller one in a quite unexpected relationship, geologically speaking.

As to the nonferrous discoveries, the Boliden Mining Company is reported to consider that the total cost for the geophysical investigation is less than 1 pct of the value of the metal products that have been won, and are to be won out of the ore deposits geophysically located. In this connection, they stress the fact that the costs for the geophysical work have been relatively small in comparison to other exploration costs, such as drilling and exploratory mining.

From only one other country, South Africa, have data come to hand with the same completeness as those furnished from Sweden. From Johannesburg, Oscar Weiss has sent some pertinent information.

One of the most outstanding geophysical surveys conducted in recent years was the magnetic one carried out from 1934 to 1937 on the Witwatersrand gold fields. It succeeded in mapping certain beds of magnetic shales which lay in a known stratigraphic relation to the gold-bearing reefs. As a result of the data thus furnished, drills succeeded in penetrating the gold-bearing formations in the West Witwatersrand area, where many drills had previously failed. The final outcome was to prove sufficient mining ground for five large new mines, each with a value of the order of $50 million, the total value therefore amounting to $250 million! The geophysical work cost approximately $168,000 or a return of $1488 to $1. One of these gold mines is claimed to be the richest in the world.

Even more astronomical are the figures concerning discoveries made in the Orange Free State, as a result of a combination of torsion balance, gravimeter, ground magnetic and airborne magnetic surveys. Work started in 1937 and the first discovery came in 1938. To date the drilling in these new Orange Free State gold fields has proven some 15 to 18 new gold mines, each with a possible life of 30 to 40 years, during which each is expected to produce some 40 million tons of ore. A conservative estimate of $50 million has been made as the value of each mine, so that the total value of this gold field is somewhere between $980 million and $1480 million. In round numbers, the value of this field is $1 billion. The total cost of the geophysical work is about $560,000, so that the return is about $1780 for each geophysical dollar expended.

Finally, gravimeter measurements were instrumental in the discovery of the Stilfontein gold mining area in the Transvaal. The Stilfontein mine itself, and two possible other developments, have a total estimated value of about $168 million. The cost of the gravimeter work directly in the area concerned was not over $6000. In this case therefore, the ratio of value of ore discovered to cost of geophysical work is $28,000 to $1.

Again the figures cited above relate the value of ore discoveries to the cost of only those geophysical surveys directly involved. The total amount of money spent on geophysical prospecting in the last sixteen years in the Union of South Africa has been estimated to be $1 million. The discoveries set forth above yield a total value of $1,438,000,000. Thus, for every geophysical dollar expended, $1418 returned like bread on the waters, but with butter and jam on both sides.

Again, a comment may be in order. In 1937, R. A. Pelletier said, at a meeting of the Geological Society of South Africa,—"It is safe to say that, in the absence of the guidance afforded by magnetometric investigations, the present results on this sector (West Witwatersrand area) could not have been obtained except at the expense of an inordinate amount of blind and haphazard drilling, which no mining house, in the twenty-five years that had preceded the introduction of these methods, had attempted to undertake."

If a balance now is struck for these two countries, Sweden and South Africa, the total cost for geophysical work amounts to $3,250,000. The total value of ore discovered by exploration programs in which geophysics played an important to a preponderant part, amounts to more than $1,610,000,000. This represents a return of $500 worth of ore discovered for every dollar spent on *all* the geophysical surveys in those two countries.

A comparison of the figures for Sweden and South Africa brings out a most unexpected facet of geophysical exploration returns. Sweden, a heavily glaciated country, represents the type of terrain to which geophysical methods have always been considered most highly applicable. The common impression has been that in unglaciated areas, geophysical techniques have a more restricted application. Yet, the ratio of return on geophysical work in Sweden averages 85 to 1, whereas in South Africa, the unglaciated country, the ratio is 1418 to 1!

The earliest discovery on this continent, by electrical means, was that of the E and G bodies of the Noranda Mines in 1924. These two bodies contained a total of one million tons of copper-gold ore and of silicious fluxing ore, but exact dollar values are not available. This survey cost about $3000 and, whatever value is put on the million tons subsequently discovered, yields a handsome return per dollar invested. A conservative figure would probably be $5 per ton, which means that $5 million worth of ore and flux was discovered as a result of an expenditure of about $3000, a return of $1650 to $1. Another electrical discovery, in 1935, was that of the Broulan Porcupine orebody in the Porcupine district of Ontario. To the end of 1949, that mine had produced over $8 million worth of ore, and reported reserves worth $315,000. This totals $8,500,000 worth of gold ore discovered largely as a result of a geophysical survey which cost about $5000; a return of $1700 to $1. Two of the Buchans Mine orebodies, in Newfoundland, were discovered as a result of electrical surveys undertaken in 1926. The total reserves of these two orebodies are reported to amount to about seven million tons of massive, high grade sulphide ore. AS&R does not release information as to the value of its ore, but if a conservative estimate of $10 per ton is made, these two orebodies are worth $70 million. The geophysical survey, at a guess, probably cost about $20,000. This makes a ratio of return of $3500 to $1.

Last year, at the symposium on "Geophysics in the Mining Industry," R. W. Drybrough of the Sherritt Gordon Mines Ltd. spoke of the discovery of a large tonnage of nickel-copper ore at Lynn Lake. He stated that diamond drilling "to date has proven over 10 million tons of nickel-copper ore with a gross value of over $135,000,000. Geophysics and geophysics alone was responsible for the discovery of these orebodies." He did not give an estimate of what the geophysical work cost but, from the data he did give, a guess might be made that it probably cost about $50,000. Double this estimate and call it $100,000 as the cost of discovering ore with a gross value of over $135 million. This makes a return of $1350 per $1 expended on geophysics.

Some of the more spectacular and better-known discoveries, ascribable at least in large part to geophysical exploration, have been described and evaluated. The roster is far from complete, and numerous discoveries as meritorius as those named, such as Quemont and East Sullivan, could be added. All the figures cited above may be added, to arrive at a more global concept of the situation. Orebodies to the value of $1,828,500,000 have been enumerated. Geophysical surveys costing a total of $3,378,000 have been listed as related to these discoveries, or, if unrelated, as having been conducted in the countries of the principal discoveries. The ratio of return then is at $540 per $1 spent on geophysics.

B&O Opens New Ore Pier

The first cargo of 26,000 tons of high-grade iron ore from Chile arrived on May 15 at the Baltimore and Ohio Railroad's new ore import pier, Curtis Bay, Baltimore. It is the first completely new facility of its type especially designed to handle the flow of foreign ores to the United States.

The 650-ft pier has two unloading towers. Each tower has a 15-ton bucket, one of which can be seen in the center of the picture. The two unloading machines have a sustained capacity of 2000 tph, and thus can unload a 12,000-ton vessel of the type shown in just 6 hr. The conveyor belt in the foreground carries the ore to a scale house where it is weighed automatically before being deposited in railroad cars waiting on the tracks below.

Open-Pit Operations at Inspiration, Arizona.

ORE CONTROL AT INSPIRATION

Careful sampling is necessary to maintain sulphide-oxide ratio of open-pit and underground ores.

By J. L. CARNE

AT Inspiration the disseminated ores occur in two formations, the Pinal schist and Schultz granite. There is no material difference between the grade of ore formed in the schist and that formed in the granite.

The chief copper minerals are, in their order of importance, chalcocite, chyrsocolla, malachite and azurite with other copper minerals occurring in limited quantities.

The original churn drilling was done by the usual procedure, the holes being put down on corners of 200-ft squares. From these results working sections on 25 and 33 1/3-ft sections were made up, from which the estimates of the mining blocks are made. These results have been found reliable and no adjustments have been necessary.

The mixed oxide and sulphide ore at Inspiration is treated by the sulphuric acid-ferric sulphate leaching process which requires a close day-by-day mine control. Good metallurgical results cannot be obtained if the ore contains too much sulphide in proportion to its oxide.

Since the amount of oxide ore available at Inspiration is limited, close control is necessary to insure that no more oxide than is necessary to maintain a 40 pct oxide and 60 pct sulphide ratio be mined currently. The over-all grade is also important and is held within strict limits in order to move the entire remaining orebody at an average grade.

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Open-pit and underground mining at Inspiration is under a single superintendent because both operations are closely interrelated. The assay of the ores based on the sampling determine, within limits, the source from which the ore is to be obtained.

Two laboratories handle the determinations, one at the mine under the supervision of the mine superintendent and the other at the leaching plant under the supervision of the leaching plant superintendent. Mine assaying is by the slop cyanide method and the leaching plant uses the electrolytic method.

The leaching plant results, which are automatically-cut samples from crushed tank feed, are the control assay and all results from the mine laboratory are corrected to this assay. If the mine sampling is not representative of the area concerned, this can lead to over-correcting in one case and necessarily under-correcting in the other. Over a period of 20 years or more the mine assay has averaged about 1½ pct higher in total copper than that of the leaching plant.

The mine office assay is primarily for control in the day-to-day mining of both underground and open-pit operations. These two ore streams join at the coarse crushing plant and make up the daily feed to the leaching plant.

The main source of underground samples is the haulage system, each car being sampled before dumping into the pockets. No special sampler is provided for this work, the trainmen being held responsible for taking the sample. This is simply a grab from the top of the car, with the supervisory force making every effort to get a fair sample from each train.

As all levels have several sources and each source is sampled separately, the trainmen are provided with several boxes to hold their samples from each train until a full sample is collected. The samples are sacked and labeled during the shift by the sampler. The weights of the samples vary, depending on the source. Thus a development area or a small-tonnage producing block will have a small sample inasmuch as only a few cars are sampled while a block producing 400 or 500 cars per shift will have 8 to 10 samples weighing about 30 lb each. The results from this sampling are available the following day.

The results from the mine sampling of the various sources are compiled into a composite assay of the production, and this is corrected monthly to the leaching plant results covering the same period of time. In this manner all sources take the same percentage of correction regardless of the grade of material produced from each area.

Special samples from draw points are taken frequently, particularly as a block approaches exhaustion. While most of the operators become quite competent to judge ore from waste visually, it is quite difficult to judge as it approaches marginal value and dilution is heavy. As a block reaches this stage special sampling is done to determine whether draw points are to be tapped or shut off. Quick results can be obtained from the mine assay office and no draw points need to remain idle very long waiting for assay returns.

As a general rule all samples of prospect drilling are sent to the leaching plant laboratory to take advantage of the more accurate methods employed, particularly as to oxide determinations.

Sampling procedure at the open-pit operation is relatively important for the following reasons: (1) controlled sulphide-oxide ratio at the leaching plant must be maintained to insure efficient recovery of the copper content of the ore; (2) it is impossible to determine the boundary between ore and waste in many places in the pit by a mere physical examination of the face; (3) irregularities in the orebody not determined by prospect drilling are disclosed in sampling by blasthole drilling in mining operations.

Four types of sampling are carried out in conjunction with the daily mining operation. These are (1) churn drill blasthole samples, (2) tripper samples, (3) waste dump grab samples, and (4) grab samples of the muck pile on the bench.

Churn drill blasthole samples are the key samples as they are the most accurate obtainable.

Benches at Inspiration are carried at 50-ft intervals. The 9-in. blastholes are drilled 5 to 6 ft below grade to prevent a hard bottom. Only the first 50 ft of the hole is sampled as this represents the material to be removed from the bench. One sample for the entire 50 ft is taken; the sludge being cut first by a modified Jones riffle sampler mounted on the deck of the drill retaining one part in 100 and then by a small hand riffle sampler into a 1 gal tin bucket retaining one part in two. Assays are run for percent of total copper and percent of oxide copper. These values are then recorded on the bench assay plans and the ore and waste areas are blocked out, using the pct of total copper as a basis. In interpolating between blastholes the value of each hole is generally computed as carrying half the distance to the next hole. For example if there are two holes, one of them ore and the other waste, then the waste-ore boundary would be midway between the holes. Only in cases of an ore hole and a marginal hole is the boundary established by giving weight to the ore hole. Benches are marked with waste-ore signs at these boundaries to show the foremen the limits of the ore zone. The average assay of the material in the blast is calculated by numerically averaging the values of holes in the blast.

Tripper samples are the day-to-day check on the areas being mined. Grab samples are taken at half-hour intervals during the shift from the discharge chutes at the tripper after the ore has passed through the primary crusher. This gives 14 samples, during an 8-hr operation, of the material going into the pit storage bins before it is transported by railroad to be mixed with the underground ore at the main crushing plant. Grab sampling from the belt at ½-hr intervals is not an accurate method of sampling, but it serves the purpose as the assay results are used only for a comparative basis. Results are reported to the general pit foreman within 24 hr so that he can compare the previous day's run with the assay values of the churn-drill holes from the blast in which the shovel was operating. These have checked out within a close limit over a 3-yr period.

Truck spotters at the waste dumps take grab samples from every fifth truck and submit a composite sample for each 2½-hr period or three samples per 8-hr shift. This grab sample is obtained by inserting a shovel under the end of the truck bed as it is raised and catching a small scoopful during the dumping procedure. The results of these samples are compared by the pit engineering staff with the churn-drill samples of the area from which the waste was removed. This comparison has been remarkably close. For example in one dump where two million tons of waste were placed for future leaching-in-place operations, the grab samples showed an excess of 4 pct in percent total copper and 1 pct less in percent oxide copper than the assay value of the material derived from the churn-drill blasthole samples. These are a check on the churn-drill samples which govern the value of the material in the dump.

Special grab samples weighing approximately 20 lb are taken occasionally from the blasted material in the pit. These are taken under the following circumstances: (1) Wagon drill or jackhammer holes are not sampled during drilling, so a grab sample is taken to determine the copper content of the material drilled and blasted by these means. (2) The foremen or others in supervisory capacity may wish to check their judgment as far as marginal material is concerned. (3) The engineers may wish a grab sample taken in areas where they feel the churn-drill blasthole assays are inaccurate due to possible salting of the sample by stringers of soft high grade chalcocite intersected by the hole.

In conclusion, sampling at Inspiration's open pit is important since the copper content of the ore from the pit and especially its sulphide-oxide ratio must be determined within a reasonable accuracy before it is mixed with the underground ore supply for treatment at the leaching plant. The flexibility of open-pit mining allows Inspiration to control its plant feed for better copper recovery. Only through an accurate knowledge of the assay value of its broken ore reserves in the pit can this sulphide-oxide ratio be maintained.

UNITED STATES

CORPORATION INCOME TAX RETURN

For Calendar Year 1950

or fiscal year beginning ....., 1950, and ending ....., 1951

PRINT PLAINLY CORPORATION'S NAME AND ADDRESS

AMERICA'S MINERAL INDUSTRY

(Name)

EVERYWHERE

(Street and number)

(City or town, postal zone number) (State)

Date incorporated ..... State or country .....

Principal business activity (See Instruction N) DEVELOPING MINERAL RESOURCES

AN INCOME TAX PROGRAM

FOR MINERAL PRODUCERS

by GRANVILLE S. BORDEN

THE program for income tax legislation presented here proposes some diminution in the current tax burden on mineral producers but it will, if enacted, eventually increase the potential and current Government revenue from the mineral industry.

The tax program stems from the following statements of facts, all of which seem axiomatic:

(1) The freedom of the United States cannot be preserved without adequate mineral reserves. Today these mineral reserves are not adequate. Great new projects for exploration, development and expansion of production must be started at the earliest possible date.

(2) Socialized mining cannot do the job; it must be done by private enterprise. But private enterprise cannot explore, discover, and increase its producing activities if the sum of its operating costs and taxes is greater than its revenue.

(3) Every productive mining enterprise supports many channels of revenue into the U. S. Treasury. These channels have intakes from profits, wages, materials, supplies, and excises on the new wealth produced. Every discovery of a commercial deposit of minerals creates new sources of national wealth, new conduits of revenue into these treasuries, and new basic materials for the military establishments. Conversely, every deterrent to discovery and production tends to impoverish the Treasury and impede the procurement of adequate supplies of minerals.

(4) Tax increases convert proven and developed ore reserves into waste, retard development of probable reserves, and tend to sterilize explorations, prospecting, grubstaking, and wildcatting.

(5) Thus in determining the proportion of the new tax burden for the extractive industries, sound judgment must be exercised because if it is too heavy, the expansion job cannot be performed.

Those who challenge this program may say "How can we meet a $71 billion budget, on a pay-as-you-go basis, without assessing heavy new tax burdens upon all of our people? Will the other taxpayers tolerate discrimination in favor of the miners?"

But additional taxes on the mineral producers will not yield more revenue as the law of diminishing returns has been invoked under existing law. The geese who lay the mineral eggs are now fighting for their lives.

Assume, that because of a relatively low tax burden there are certain mineral producers who may be unjustly enriched because they have been successful in procuring minerals indispensable to war. In such cases these profits can be recaptured under Section 102 of the Internal Revenue Code (which levies a surtax penalty on corporations improperly accumulating surplus) if they are not plowed back into productive effort or declared as dividends taxable at the highest bracket of the corporate stockholders.

Here, then, is a seven-point tax program designed to foster mineral exploration and development:

(1) The maximum tax on the income derived from mining minerals or producing oil and gas should be 25 pct. Under existing law the profits on corporate producers are subject to 25 pct normal tax plus 22 pct surtax plus 30 pct excess profits tax with a ceiling of 62 pct of the taxable income. This ceiling should be 25 pct of the profit (computed with cost depletion).

MR. BORDEN, an AIME Member, is a leading tax consultant for the mineral industry.

When an operator exploits a mineral deposit in the normal course of his producing business, he is actually selling it in a series of sales. If he sold it to another operator for a price to be paid as the buyer mined the ore, the profit would be a long term gain and taxable at a capital gain rate of 25 pct. To tax the operator who realizes these gains in the normal course of his business at the ordinary normal tax rates, the surtax rates, and the excess profits tax rates, is discrimination against the producers of minerals, oil, and gas.

Congress has recognized these principles in taxing profits derived from cutting timber (Section 117 (k) of the Internal Revenue Code). In such cases the profits are taxed at capital gain rates of 25 pct. Here Congress has recognized that the tax on profits realized should be the same regardless of the fact that the timber is sold on the stump or whether the owner cuts the timber with his own equipment.

(2) As an alternative to the first proposal, depletion allowances based upon a percentage of income should be increased to a point where the tax on the sale of a mineral deposit in the normal course of operations cannot exceed the long term capital gain rate of 25 pct. Although it is true that the depletion allowances tend to alleviate the impact of this discrimination, the cases where there is a complete cure under the existing tax rates are rare. All the arguments on the merits of percentage depletion should be confined to the allowances which reflect tax reductions below this 25 pct ceiling.

On reliable authority, the so-called percentage depletion loophole battle will be waged again in the 82nd Congress. Evidence of the presence of this issue has appeared in the press and in many reports from Washington. In the light of the facts presented here, Congress should not only reject proposals to decrease the rates, but actually sanction increases.

(3) The income realized from exploiting any deposit of mineral, oil, or gas should be exempt from the excess profits tax. As shown above, such income is gain from the sale of a capital asset in instalments or in a series of sales. Congress has granted this exemption for income derived from mining certain strategic minerals. This same exemption should be extended to the income from mining all other minerals, especially critical minerals.

Taxpayers will not speculate if they can retain only a small minority of the profits to be won from a lucky discovery. The take-home profit after excess profits taxes are paid is not ample to support new prospecting or development ventures. Would anyone bet on a "long shot" at the race track if 77 pct of the winnings were to be paid as a tax? Moreover, producers will be reluctant to accelerate production if excess output is prey for any excess profits taxes. They will exploit orebodies at normal rates and pay no excess profits tax.

(4) In determining taxable income, the producers of minerals should be entitled to deduct from gross income, at any rate that they may desire, all capital invested in procurement of critical materials. This prerogative should extend to all capital items, whether expended for exploration, development, or increasing production.

Capital recoverable as deductions for depreciation should be recoverable at rates chosen by the taxpayer. When all the cost has been deducted, no more depreciation would be allowed. Possibly as an alternative a ceiling of 20 pct per annum could be prescribed for all cases where the normal rate is less than 20 pct. Such an amendment would counter the rule requiring recovery of the depreciation sustained in years of operating losses—a rule that is particularly unfair to producers of minerals, oil, and gas because of the technical limitations on net loss carry-over deductions.

Such amendment would effect substantial economies in manpower and expense for the Government and the taxpayers. Hundreds of employees of the National Security Resources Board now are engaged in the task of reviewing applications for certificates of necessity, adding to the congestion in Washington. Thousands of employees of taxpayers throughout the country are engaged in preparing these applications for taxpayers. They could all utilize their energies for more constructive activities. Their only job now is to determine whether a facility is an "emergency facility."

Taxpayers should be allowed to claim in their income tax returns the 20 pct depreciation rate on any facilities which they may believe to be "emergency facilities." Bureau rulings could be procured on borderline cases. Revenue agents in the field could pass on the claims upon audit of the returns. Where the classification is clear, the 20 pct rate would be allowed and no additional expense would be involved. Where differences of opinion arise, the taxpayer would have all the usual legal remedies available to determine whether or not the facility is an "emergency facility."

(5) In 1940, when net operating losses were granted as carry-over deductions, clever opponents of percentage depletion buried obscure technical provisions in Section 122 (b) and (c) of the Internal Revenue Code which, in most cases, deprive the producers of minerals, oil, and gas of any benefits from these rights to deduct operating loss carry-overs or carry-backs. Space does not permit a clear explanation of this matter, but the provisions are discriminatory and should be deleted both prospectively and retroactively.

(6) The law should be amended so as to assure producers that no income taxes will be assessed on the proceeds of a new venture until there is clear evidence that the investment will be redeemed. Canada, it should be noted, grants new mining ventures tax exemption on the income from the first three years of production.

(7) Shareholders in corporations producing minerals, oil, or gas should be entitled to regard a portion of every distribution of the corporation as redemption of a part of the cost of the shares. Under existing law if the distributing corporation has earnings or profits, the distribution is a taxable dividend. Generally the taxpayer must wait until the corporation exhausts its mineral deposits and goes out of business before there can be any recovery (except by intervening sale) of the cost of the shares. Then the recovery is generally a long term loss, subject to all the limitations on such losses. Canada, however, allows percentage depletion deductions against dividends paid from the earnings of mines.

If this program were put into effect it would stimulate mineral procurement and increase the flow of money into the national treasury. It cannot logically be construed as action which unfairly favors the producers of minerals, oil and gas and as discriminatory against other taxpayers of the country.

Diesel Truck Haulage Through Inclined Adit

by V. C. Allen

THE Tri-State Zinc, Inc., Galena, Ill., was confronted with the problem of securing ore from a deposit because the hoisting shaft was several thousand feet from the mill. The orebody is several thousand feet long, averaging 200 ft in width and 60 ft in height and opened up by vertical shafts some 300 ft deep. Mining is by the room-and-pillar method. During the initial operation the ore was loaded by conventional electric ½-yd boom-and-dipper shovels and hauled to the shaft by 8-ton diesel trucks. This underground ore loading and hauling was well adapted to the conditions and productive of low costs per ton. However, with the mill situated as mentioned, a triple handling of all broken rock was necessary: 1—from the stope to the shaft by truck, 2—up the shaft by skip or can into the surface hopper, and 3—by truck from the surface hopper to the crushing plant at the mill. In addition to the repeated handling, serious troubles were encountered during the winter because of freezing in the shaft hopper.

Consideration was given to either moving the mill to the new orebody or to the construction of a second mill. The presence of other orebodies to be mined at a later date made the first alternative impractical while the capital outlay for a second mill, when the present plant of approximately 850 tons per day was deemed sufficiently large for the total reserves, made the second alternative also unwise. It was decided to retain the mill in the original location and continue to move the ore to it.

The idea of driving an inclined adit from the surface to the bottom of the orebody suitable for truck haulage and big enough to allow the passage of all mechanical equipment was conceived. Among the apparent advantages of such an incline were: 1—Direct haulage from the stope to the mill without rehandling. 2—Elimination of virtually all grizzlies. Trucking from underground to the mill would do away with all hoppers, chutes, gates, and skips and make the maximum rock size dependent solely on the size of the shovel dipper at the mine and the crusher opening at the mill. 3—Less secondary blasting would be needed. 4—Ease of transporting equipment and supplies underground. Shovels and trucks could be taken through the incline intact. 5—Equipment could be brought to the surface for repairs and servicing without loss of time. The same advantages of ease in moving would be present in the handling of men, steel, powder, and supplies. 6—There would be far less difficulty in increasing the amount of tonnage that could be moved by truck up an incline than would be found in attempting to increase the capacity of a shaft. 7—All the broken ore in the stopes would serve as bin capacity, as it would take the breakdown of all of the loading and hauling equipment to have the same effect as a delay in shaft hoisting. 8—All danger of men being trapped in the mine as a result of shaft fire or power stoppage would be eliminated. 9—Virtually all trouble from severe winter conditions would be eliminated by the direct haul underground to the mill.

The decision was made to proceed with the driving of an inclined adit. The topography of the surface between the orebody and the mill was such that it was possible to locate the portal at a point 170 ft above the mine floor and 1800 ft horizontally from the central point of the orebody to the south and 2500 ft from the mill to the north. A grade of 10 pct was found to be optimum for continuous truck haulage when the various factors of speed, safety, and truck maintenance were all considered. The incline as driven was consequently 1700 ft long on 10 pct grade and 12 ft high by 17 ft wide in cross section. The tunnel-driving equipment was chosen so that it could be used in mining after the completion of the tunnel. Drilling was done with a jumbo with two Joy jibs mounting 3-in. drills, loading with an Allis-Chalmers diesel-powered, front-end loader of approximately 1¼-yd capacity, and hauling by Koehring Dumptor trucks of 8-ton capacity, diesel-powered. The width of the tunnel allowed the end loader and Dumptor to be placed abreast. Since the Dumptors can be driven either forward or backward with equal facility, loading was accomplished without turning around either machine throughout the loading operation. The crew in addition to the tunnel foreman was comprised of three men per shift at the start and in the later work, four men. Each crew could perform any part of the working cycle. If the drilling was completed and the round blasted in the middle of a shift, the same men would proceed with the loading and hauling. Since the mine already had been drained to the bottom levels, no water was encountered. At the halfway point the tunnel was widened for approximately 100 ft to permit trucks to pass.

The total cost of the tunnel excluding the capital outlay for equipment, which was all continued in use in the subsequent mine operation, was $60,363.00 or $35.50 per ft.

The tunnel was completed at the end of June, 1949 and has been in continuous use since that time. In the five months from July to November inclusive, 106,049 tons have been transported to the mill or an average of 835 tons per day. No unforeseen disadvantages have been encountered and the advantages which had been predicated before the adit's construction have been more than realized.

As previously mentioned, the deposit is worked by the room-and-pillar system with occasional faces up to 125 ft high. Except in driving development drifts when diesel-powered, front-end loaders such as were used in the tunnel are employed, all shoveling is done by ½-yd boom-dipper type shovels electrically driven. These units need a width of 25 ft and a height of 14 ft in which to operate. All hauling is by diesel trucks, mainly Koehring Dumptors. Roads are maintained with caterpillar tractors and a road grader. The tonnage output from the

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Fig. 1—Diesel truck haulage through inclined adit.

mine is limited by the capacity of the mill, which is approximately 850 tons per 24 hr. The mine is operated in two shifts; all drilling and blasting on the day shift, 7 a.m. to 3:30 p.m.; and loading and hauling on both the day and night shift, 7 p.m. to 3:30 a.m. The shifts are separated by a 3½-hr gap to allow powder smoke to clear. The loading and hauling crews on each shift are comprised of four men, one shovel operator and three truck drivers using three Dumptors similar to those used in the adit. In some instances when it is desired to get rock from several points simultaneously, two shovels are used. In such cases one shovel and operator will load two trucks, each with a driver. The other shovel operator will both load and drive the truck. The daily output of between 800 and 900 tons thus is loaded at the stopes and hauled to the mill crusher plant by a total of eight men or over 100 tons per man shift. The loading and hauling could be done on one shift with fewer men if there were sufficient hopper capacity at the mill.

The rock from the mine is dumped directly into a 40-ton hopper feeding into an apron feeder ahead of a 36x21-in. jaw crusher. The bin capacity between the coarse crushing plant and the mill proper is approximately 300 tons. There has never been any question of lack of mill feed as the haulage system is flexible to the demands of the mill. Broken rock stored in the stopes can be made immediately available to the mill. Conversely, any delay or shutdown in the mill has no effect on the underground operation except that the four men engaged in loading and hauling become idle. The occasional boulder too large to pass through the grizzly ahead of the apron feeder, bars set 20x30 in., are so few in number that they are handled by the truck drivers without additional help. All trucks are brought to the surface shop for daily servicing and repair work. Minor jobs on the loading equipment are made underground. The same applies to the jumbos, either tractor-mounted or truck type.

Since the mine is shallow and is opened by two shafts and the inclined tunnel, little mechanical ventilating aids are needed. One blower of 24,000-cfm capacity blows fresh air down a shaft, and one smaller blower forces fresh air down a drill hole. Since both shafts are covered, the incline serves as an upcast. Recent tests show 30,000 cfm discharging from the incline with the carbon monoxide content in the tunnel never exceeding 10 parts per million, far below the permissible amount. The aldehyde in the exhausts is barely noticeable in the adit itself despite the constant traffic of the Dumptors, a trip each way about every 5 min. Men are transported from the surface change house into the mine by a diesel truck with a removable housing and equipped with benches. This housing is necessary only during the winter months when the sudden change from the warm mine to occasional sub-zero surface temperature in wet mine clothes would be too severe.

Total mining costs including haulage are $0.9708 per ton. A partial breakdown of these costs follows:

Breaking	
Labor, including compensation and Social Security	$0.2564
Explosives	0.1451
Power	0.0317
Repairs and supplies	0.0652
Total	0.4984
Loading	
Labor, including compensation and Social Security	$0.0641
Power	0.0039
Repairs and supplies	0.0230
Total	0.0910
Hauling	
Labor, including compensation and Social Security	$0.0913
Diesel oil	0.0197
Repairs and supplies	0.0517
Road maintenance	0.0036
Total	0.1663
General	
Supervision, including compensation and Social Security	$0.0683
General labor	0.0584
Ventilation and lights	0.0074
Repairs and supplies	0.0811
Total	0.2151
Total overall costs	$0.9708

The results of the operation of the past five months have proved that mining by truck haulage through inclined or horizontal adits, especially in deposits of a type which permit loading into trucks at the ore faces, offers many advantages over vertical or inclined shafts.

In addition to the benefits derived in mining a single deposit, it also would appear that if a number of scattered orebodies are to be treated through a central mill much duplication of equipment and saving in manpower would result through the use of adits since it becomes easily possible to so arrange the various stages of the combined operation as to permit moving all the equipment from one mine to the other. In a similar operation under normal shaft hoisting, each mine or shaft would have to be separately equipped both with surface hoisting plant and underground units.

There is no apparent reason why the use of inclined adits would have to be confined to very shallow mines. When it is realized that driving a 10 pct incline with the type of equipment such as was used here is entirely similar to drifting, it becomes apparent that its total cost to reach a certain vertical depth is possibly no greater than would be entailed in sinking, to the same vertical depth, a three-compartment shaft equipped with underground skip pockets and with its necessary surface equipment including hoist and ore bins. There is undoubtedly a point at which the length of the haul up the adit would limit its practical use but no attempt has been made to determine this. Further experience and new types of equipment may permit considerably higher grades than 10 pct and thus lessen the length ratio between adit and vertical shaft.

Efficiency and Sharpness of Separation in Evaluating Coal-Washery Performance

by H. F. Yancey and M. R. Geer

Various criteria for evaluating the performance of coal washeries are discussed critically, with particular reference to ideas developed at the First International Conference on Coal Preparation held in Paris in June 1950. Criteria that relate only to the sharpness with which a cleaning unit separates coal from impurity are compared with those that reflect loss of coal or quality of products.

THE performance of coal-washing equipment, that is, the effectiveness with which coal and impurity are separated, is a subject of undisputed interest to all concerned with the preparation of coal. Through the years much has been written in both American and European literature on the performance of coal-washing equipment and its interpretation, but until recently no effort has been made to consolidate this wealth of information into a single, comprehensive treatment of the subject. A splendid effort in this direction was made at the First International Conference on Coal Preparation held in Paris in June 1950 in which representatives from virtually every coal-producing country participated. Although the scope of the conference covered the entire field of coal preparation, many of the sixty-odd papers and a great deal of the discussion dealt with the subject of evaluating washery performance. Prominence was given this subject by the Centre d'Etudes et Recherches, des Charbonnages de France, which sponsored the conference.

This research organization, generally referred to as Cerchar, was formed in 1948 following the nationalization of the French coal industry. Since that date it has conducted an intensive study of coal preparation. Perhaps because of a fresh viewpoint, Cerchar realized immediately that complete information on the performance of French washeries and a thorough understanding of the mechanism of gravity separation were the fundamental prerequisites in a program to improve preparation practice. For this reason Cerchar concentrated on obtaining performance data and on a comprehensive study of methods of evaluating such information. Some idea of the magnitude of this work will be appreciated from the fact that 175 performance tests were made in 44 plants.

The work performed by Cerchar emphasized a condition that is recognized by many of those concerned with coal preparation, namely that the lack of uniformity in presenting data on washery performance, the diversity of methods used in evaluating such information, and the frequent confusion of the terms related to performance have been prime factors militating against the progress from art to science. Thus, Cerchar feels that standardization of the methods employed for evaluating washery performance, not only in France but in the entire world, is essential to progress, and the prime objective of the Paris conference was to seek international standardization of the evaluation methods advocated by Cerchar. At the conclusion of the conference the question of standardization was referred to the International Standards Organization.

A careful study of the dozen papers on the subject of evaluating washery performance presented at the conference reveals that none of the methods is new; most of them date back over a decade. Nevertheless, the intensive scrutiny of these methods brought about by the conference unquestionably has resulted in a valuable exchange of ideas and a clarification of thought that could scarcely be achieved in any other way.

The object of the present report is to make available to the American coal industry the ideas developed at the conference which seem most important from an American viewpoint and to provide a critical analysis of some of the evaluation methods advocated by Cerchar. The various methods of evaluating washery performance are illustrated partly with data that have been published in American literature, and some new data have been obtained as the result of experimental work undertaken since the conference to provide information on certain controversial points. An English translation of the proceedings of the conference, including the discussion as well as the papers, will be available,[1] and previous to the conference Coal Age[2] published a very brief description of some of the principal evaluation methods used by Cerchar.

Americans will appreciate as well as do the French the desirability of standardizing both the termi-

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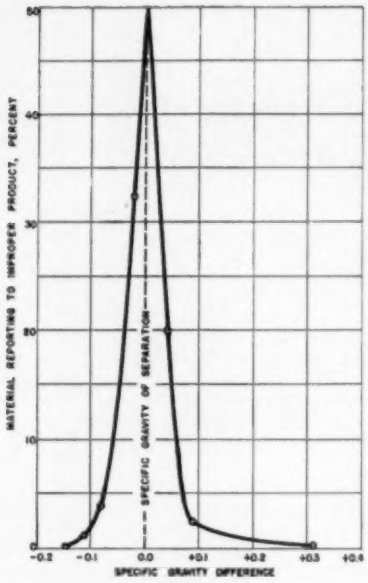

Fig. 1—Error curve for gravity separation.

nology and the methods of presenting washery performance data. However, the idea of rigid standardization will have less appeal here than in France where nationalization of the coal industry has brought centralized responsibility for all coal-preparation work.

Mechanism of Gravity Separation

The subject of evaluating washery performance can hardly be approached without the prelude of a brief statement concerning the mechanism of gravity separation. The ideal cleaning process, from the standpoint of performance, would be one in which all coal lower in density than a predetermined value would be recovered in the clean product, and all material of greater density would be rejected as refuse. Naturally, no cleaning process achieves this goal. The type of separation between coal and impurity which actually is accomplished may be illustrated best by Fig. 1.

Coal of low density and impurity of high density report largely to their proper products—washed coal and refuse, respectively. But as the density of separation is approached, the proportion of material reporting to an improper product increases rapidly. In fact, the density of separation can be defined best as the density of the material in the raw coal that is distributed equally between washed coal and refuse. The shape of this curve is like that of a Gaussian error distribution curve, and a mathematical analysis of gravity separation demonstrates that it is governed by the law of probability.

The imperfect separation of materials of intermediate density illustrated in Fig. 1 is characteristic to some degree of all coal-washing processes regardless of their mode of operation. The shape of the curve is determined largely by the inherent difficulty of stratifying materials differing only slightly in density. With processes that are capable of effecting a sharp separation between coal and impurity, such as heavy-medium units, the two limbs of the curve lie close together and approach or reach the 0 axis at densities not far removed from the density of separation. With processes that are unable to make a sharp separation between coal and impurity, the two limbs of the curve are more widely separated and approach 0 only at densities substantially removed from the density of separation. In some cases neither limb reaches the 0 axis.

It will be noted that the error curve shown in Fig. 1 is not symmetrical about the abscissa representing the density of separation but is skewed at higher densities. This skewness, which represents less perfect separation of the material of higher density, characterizes the error curves for most separations made at the usual washing densities.

The concept of representing a gravity separation as an error curve and defining the density of separation as the density of material that is divided equally between the two washery products dates back to a paper published by Tromp[3] in 1937. Terra[4] developed the probability concept of gravity separation along different lines in 1938.

Classification of Performance Criteria

The various criteria that may be used in evaluating washery performance may be classified according to the degree to which they are dependent upon the character of the raw coal being washed; some are directly dependent, others are much less so.

The performance of any washing unit depends upon three primary factors: the density composition of the feed, the density of separation, and the sharpness with which the unit separates coal from impurity. All three factors influence directly the quantity and quality of the washed coal and refuse, and hence any criterion of washery performance that is based on the quantity or quality of the products is influenced directly by all three factors. Thus, as is well known, the ash reduction effected by a washing unit, or the ash content of the refuse it produces, tell little about the inherent characteristics of the unit, for both values reflect the influence of the type of coal being washed and the density of the separation.

In the routine control of a washery, performance evaluation by means of the ash contents of the clean coal and reject or by testing these products on a control float-and-sink bath is entirely satisfactory. The composition of the raw coal does not vary greatly, and the density of separation is reasonably constant. Moreover, the quality of the washed coal and the yield are the factors of prime interest to the operator.

Often, however, the criterion of performance desired is one reflecting the inherent ability of the washing unit to make a sharp separation between coal and impurity, and this criterion must be as free as possible from the effect of either the character of the raw coal or the density of separation. Only in this way can the performance of washeries treating coals of dissimilar character and making separations at different densities be compared directly. Such criteria are useful in formulating performance guarantees for new plants and in calculating the yield and quality of products obtainable by treating a new coal in an existing plant of known performance characteristics. In other words, they assist in translating the washability data obtained from float-

and-sink tests into the yields and ash contents of a washing operation.

Dependent Criteria

The number of possible ways of utilizing some measure of the quality of the clean coal and refuse produced by a washer to characterize its performance are almost unlimited, and many such methods have been proposed through the years. Hence, the present discussion will be confined to only a few criteria that have found wide acceptance or for other reasons are of special current interest.

Efficiency: Efficiency formulas belong to the class of criteria that are influenced both by the character of the raw coal and the density of separation as well as by the sharpness with which a washing unit separates coal from impurity. A number of efficiency formulas have been proposed from time to time, but the one used most widely has been the Fraser and Yancey formula for recovery efficiency advanced by the Bureau of Mines in 1922.[8] This formula is the ratio, expressed in percentage, of the yield of washed coal to the yield of float coal of the same ash content shown to be present in the feed by specific-gravity analysis. It is written as follows:

$$\text{Efficiency} = \frac{\text{Yield of washed coal}}{\text{Yield of float coal of same ash content}} \times 100$$

Cerchar uses this formula, terming the value obtained "organic efficiency," and the discussion at the Paris conference disclosed the fact that it is the one criterion of washery performance that is universally recognized throughout the world. Doubtless the wide acceptance of the formula is attributable to its simplicity and to the fact that it conforms with the usual engineering concept of efficiency, that is, output divided by input.

Despite such wide use, some confusion regarding the Fraser and Yancey formula was evident at the Paris conference. Actually, two efficiency formulas, rather than one, were advanced in 1922. The second formula was written as follows:

$$\text{Efficiency} = \frac{\text{Yield of float coal}}{\text{Yield of washed coal}} \times \frac{\text{Raw-coal ash} - \text{washed-coal ash}}{\text{Raw-coal ash} - \text{float-coal ash}}$$

In this formula the yield of float coal and the float-coal ash refer to the product obtained by a float-and-sink separation at a specific gravity representing the most profitable separation of the coal. In practice, the most profitable separating density generally is difficult to determine, and hence this equation has not been used by the Bureau of Mines for many years. Moreover, depending upon the density selected to represent the most profitable separation, this formula may give values of over 100 pct.

The most serious shortcoming of the first or output-input efficiency formula, also called recovery efficiency, is that when no refuse is removed the efficiency is 100 pct. For example, pneumatic cleaning units treating unsized feed generally remove no refuse finer than about 28-mesh in size, and hence the efficiency for the treatment of the finest sizes in such units often is 100 pct, which is higher than the efficiencies obtained on the coarser sizes in which the ash reduction is much better. The significance of such an efficiency value is that it represents no loss of clean coal in these sizes rather than indicating perfect separation.

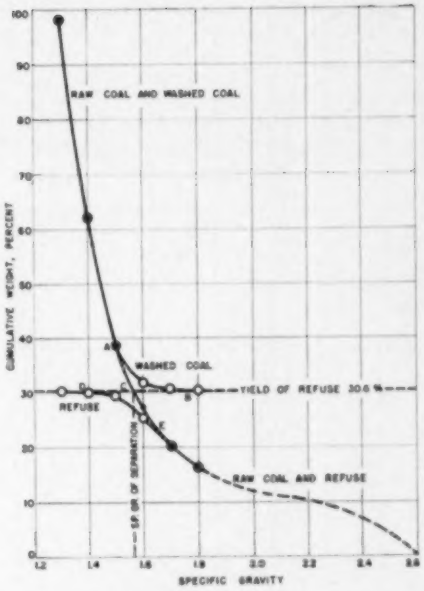

Fig. 2—Yield-specific-gravity curves for raw coal, washed coal, and refuse plotted to show "triangles of error."

Use of the efficiency formula requires only a specific-gravity analysis of the raw coal and the ash content of the washed product, and in many cases the calculation of efficiency from these data is entirely satisfactory. However, with a friable coal, and more particularly with one containing intergrown particles from which coal is freed readily by degradation, it is preferable to calculate efficiency from the composite specific-gravity analysis of the washery products. In this way the effect of degradation in the washing process is eliminated, and the washing unit is not given credit for the recovery of particles of coal that were not present as such in the feed. In rare instances efficiencies of over 100 pct have been reported as the result of degradation when the specific-gravity analysis of the raw coal rather than a composite specific-gravity analysis was used.

The field of application of efficiency values is clearly defined. Since efficiency is influenced by the character of the raw coal being treated and the density of separation as well as by the inherent characteristics of the washing unit, washers treating coals of different density composition or operating at different densities of separation cannot be compared directly on the basis of this criterion. In a given cleaning unit, a coal containing a high proportion of intermediate-density material cannot be cleaned with as high efficiency as a coal containing little material of intermediate density. Similarly, a separation at a lower density cannot be made with as high efficiency as a separation at higher density.

Misplaced Material: One of the simplest, and certainly one of the most obvious, evaluations of washery performance is the quantity of sink material in the washed coal and float material in the refuse. If the washery products are tested at the density at

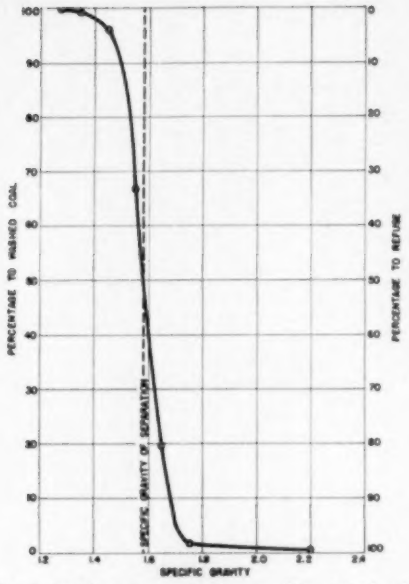

Fig. 3—Distribution curve for heavy-medium separation in 2-ton per hr pilot plant.

which the washing unit is operated, the sink in the washed coal and float in the refuse represent material that has been misplaced. An early example in the American literature of the concept of misplaced material as an evaluation of washery performance is found in the work of Lincoln.[6] The use of the quantity of misplaced material as a criterion of washery performance was employed by the Bureau of Mines in 1938,[7] and in 1950 Anderson[8] proposed the use of this criterion as an efficiency value to replace the Fraser and Yancey formula.

British literature also contains examples of this criterion, and in 1947 R. T. Hancock[9] defined the density of separation as being the density at which the total quantity of misplaced material is a minimum. Cerchar likewise has employed the quantity of misplaced material as a criterion of washery performance, using the term "error by strays" for this quantity. Cerchar has concluded, somewhat at variance with Hancock, that at the density of separation the amounts of sink in the washed coal and float in the refuse, when expressed as percentages of the feed, are equal, and the error by strays is defined as either the amount of sink material in the washed coal or float in the refuse at the density of separation.

Fig. 2 illustrates a type of plot originally developed by Heidenrich[10] and now used widely by Cerchar. The curve for raw coal represents the cumulative percentages of sink material. The refuse curve also is plotted as cumulative sink, the percentages being expressed in terms of raw coal. The curve for washed coal represents the specific-gravity composition of the washed coal expressed as a percentage of the feed and is plotted as cumulative percentage float. To place the washed-coal curve in proper relation to the curves for raw coal and refuse, the cumulative float values are plotted as additions to the percentage yield of refuse. In other words, the cumulative percentage of float in the washed coal is plotted from an axis representing the yield of refuse. The curves shown in Fig. 2 are plotted against specific gravity, but similar curves are also obtained by plotting against ash content.

This diagrammatic representation of the results of a washing operation, while perhaps not easy to grasp because of the method of plotting, has the merit of showing in a pictorial way the type of separation obtained in a washing unit. The washed-coal and refuse curves coincide with the raw-coal curve in the ranges of low and high density, but diverge from it as they approach the density of separation. The density of separation obtained from this type of plot, incidentally, is not the same as that previously defined as the density of material that is divided equally between clean coal and refuse; it is simply the density of the float-and-sink bath that would be required to give a yield of float coal equalling the yield of clean coal obtained in the washing operation. Moreover, this value for the density of separation differs from the value frequently defined in American practice as being the density of the float-and-sink bath that would yield a float product having the same ash content as the washed coal.

The divergence of the washed-coal and refuse curves from the raw-coal curve forms "triangles" ABC and DCE. These triangles are termed "triangles of error" by Cerchar, and it is obvious that their area is related to the quantity of misplaced material and therefore can be used to characterize the quality of the gravity separation.

Both the area of the triangles of error and the quantity of misplaced material are, like efficiency, influenced by the character of the raw coal, the density of separation, and the sharpness with which the washing unit separates coal from impurity. In fact, Cerchar employs a method of calculating efficiency from the area of the triangles of error, and the efficiency value obtained in this way is in many cases the same as that obtained by using the ratio of washed coal to float coal employed in the Fraser and Yancey formula.

Independent Criteria

As early as 1912 David Hancock[11] evaluated washery performance by showing graphically the proportions in which each density fraction of raw coal was distributed between clean coal and refuse, but 25 years elapsed before Tromp[2] plotted these proportions against density to obtain a distribution curve. This type of curve, which was also developed

Table I. Specific-Gravity Analyses and Distribution Data

Specific Gravity	Specific-Gravity Analyses, Pct of Product			Specific-Gravity Analyses,[a] Pct of Feed		Distribution,[b] Pct		
	A Feed	B Washed Coal	C Refuse	D Washed Coal	E Refuse	F Feed	G Washed Coal	H Refuse
Under 1.30	1.7	2.5	0.0	1.7	0.0	100.0	100.0	0.0
1.30 to 1.40	36.3	52.2	0.3	36.2	0.1	100.0	99.7	0.3
1.40 to 1.50	22.9	31.8	2.6	22.1	0.8	100.0	96.5	3.5
1.50 to 1.60	11.8	11.3	12.8	7.9	3.9	100.0	66.9	33.1
1.60 to 1.70	6.6	1.9	17.2	1.3	5.3	100.0	19.7	80.3
1.70 to 1.80	4.5	0.2	14.2	0.1	4.3	100.0	2.2	97.8
Over 1.80	16.2	0.1	52.9	0.1	16.2	100.0	0.6	99.4

[a] Column D obtained by multiplying column B by 69.4 pct, the yield of washed coal; column E obtained in corresponding manner.
[b] Column G obtained by dividing column D by column A.

independently by the Bureau of Mines in 1938,[12] provides means for evaluating the sharpness with which a washing unit separates coal from impurity. The evaluation is substantially independent of either the character of the raw coal or the density of separation and thus provides information that is related to the inherent characteristics of the washing unit. Thus, the distribution curve and various criteria that can be derived from it differ fundamentally from the criteria described previously.

As an illustration of the distribution-curve method of expressing washing results, Table I gives specific-gravity analyses of the feed, washed coal, and refuse from a test made in a laboratory, heavy-medium, pilot plant of 2 tons-per-hr capacity. The distribution data are shown in the table, and the curve in Fig. 3. In constructing the curve, the distribution data for each density fraction are plotted against the mean density of the fraction, the mean density being the density at which half of the material would float and half would sink. Assumptions are required in plotting the lightest and heaviest fractions. Material lighter than 1.30 sp gr is plotted at 1.28, but any errors in assuming the mean density of this fraction generally have little influence on the shape or the position of the curve. The fraction heavier than 1.80 sp gr is plotted at 2.20 or 2.30, depending upon judgment concerning the character of this material; the validity of this assumption often has considerable influence on the shape of the curve. Generally it is sufficiently accurate to plot the data for fractions of intermediate density at the arithmetic average of the limiting densities.

Fig. 3 indicates that none of the lowest gravity coal was lost in the refuse product, and almost no impurity heavier than 1.80 sp gr entered the washed coal. The specific gravity at which the curve crosses the 50 pct weight ordinate, 1.59, is the specific gravity of separation; material of this density was divided equally between washed coal and refuse. A distribution curve representing a perfect separation would show all coal lighter than the density of separation going to the washed product and all heavier material going to refuse, with the curve passing from 100 pct to 0 on the abscissa representing the density of separation. The degree to which the distribution curve for a washing operation approximates this theoretical or perfect shape is a measure of the sharpness of the separation made by the unit.

The distribution curve generally is plotted directly against density as shown in Fig. 3, but for the purpose of comparing distribution curves representing separations at different densities, the data can be plotted against the difference between the mean density of the fraction and the density of separation. The relationship between a curve plotted in this way and the plot shown in Fig. 1 becomes evident if the portion of the curve in Fig. 3 for densities less than the density of separation is revolved 180° about the 50 pct ordinate.

Error Area and Probable Error: The distribution curve is a convenient means of showing the sharpness of the separation effected by a washing unit and has found increasing use both in America and Europe. However, curves are a less convenient means of comparison than figures, and therefore several numerical criteria have been derived to characterize with a single figure the magnitude of the deviation of the distribution curve from the curve that would represent a perfect gravity separation. One such criterion is the area lying between the distribution curve and the lines representing perfect separation; this area has been termed "error area." If distribution curves are plotted to a fixed scale, the error areas provide a convenient means of comparing sharpness of separation. Driessen[16] advocated the use of 1 cm for each 2 pct of weight on the ordinate scale and for each 0.1 in specific gravity on the abscissa scale, with the area expressed in square centimeters. Cerchar also has adopted this scale. The same numerical result is obtained if inches are substituted for centimeters in plotting and the area is determined in square inches. Thus the error areas given in this report are directly comparable with those reported in European literature.

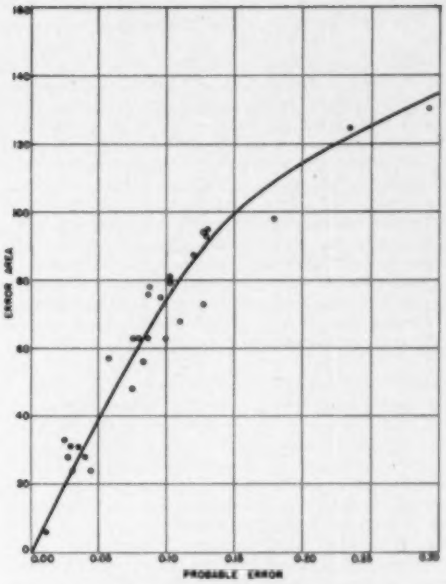

Fig. 4—Relation between error area and probable error.

As another method of characterizing the distribution curve with a single figure Cerchar has adopted a criterion originally developed by Terra[4] called "écart probable," which is variously translated as probable error or probable deviation. Numerically, the probable error is 50 pct of the difference between the specific gravities at which the distribution curve crosses the ordinates representing 25 and 75 pct recovery in the washed product. Thus, if the distribution curve is a straight line in the range between these ordinates, and many curves do approximate a straight line in this range of density, the probable error is simply a measure of the slope of the curve.

Both error area and probable error are used to indicate sharpness of separation and Cerchar expresses the relation between them mathematically. However, as shown by the plot of these two criteria in Fig. 4 for about 30 washing tests, the relation is only a general one. The choice of which criterion to use probably is largely a matter of individual preference. Probable error has the advantage of being more easily determined than error area, for the latter requires the use of a planimeter. On the other

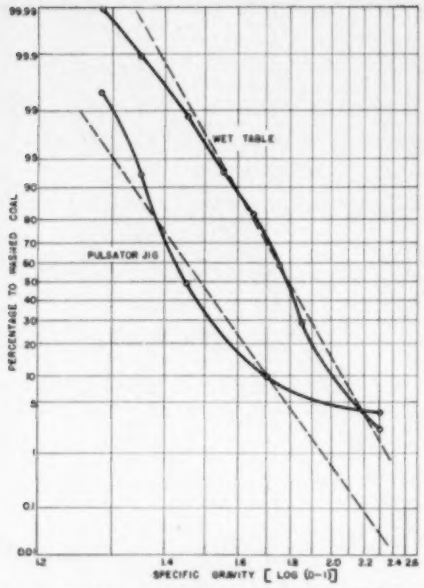

Fig. 5—Distribution curves plotted on logarithmic-probability scales.

hand, error area takes into account the entire distribution curve, while probable error evaluates only the portion of the curve in the range of intermediate density. Probable error thus does not reflect directly the disposition made by the washer of the lightest and heaviest fractions of the raw coal, and in most cases the disposition made of these fractions is of far more practical importance than the treatment of the intermediate-density material. Despite this criticism, however, Fig. 4 demonstrates that a general relationship between the two criteria does exist.

Distribution Curve Transformation

The advantages which accrue when a relationship can be plotted as a straight line are well appreciated: two parameters serve to describe the relationship completely, fewer data are required to obtain the same degree of accuracy, errors are more conspicuous, and interpolation is facilitated. With these objectives in mind, Cerchar advocates plotting distribution curves in straight-line form. Since as has been pointed out, a gravity separation can be regarded as a probability function, the ordinates of the distribution curve can be plotted on a probability scale to convert the curve to an approximation of a straight line. The scale of abscissa required to give the closest approach to a straight line is less easily defined, however.

Over eight years ago Vissac[14] submitted a paper to the AIME in which he advocated plotting distribution curves as straight lines, but this portion of his paper was not published; he employed an abscissa scale of log (d—d_o), d being density and d_o being the density of the pure coal. Tromp,[15] on the other hand, employs a logarithmic scale of density raised to the 0.6 power. Cerchar uses three separate abscissa scales, depending on the type of washing unit. An arithmetic scale is employed for plotting the results of heavy-medium separations, a scale of log (d—1) is used for processes employing water as the separating medium, and a scale of log d is employed for pneumatic processes.

Fig. 5 shows two distribution curves plotted on a chart having a probability ordinate scale and an abscissa scale of log (d—1). One curve represents the operation of a pulsator-type jig treating a feed of 3 to 1¼-in., and the other is for the operation of a wet table on 3/32-in. to 0 coal. Neither curve is a straight line, but in the case of the table operation the deviation from straight-line form is not great; a maximum error of about 5 pct in weight would be incurred in plotting this curve as a straight line. The data for the pulsator jig, however, show greater curvature, and if plotted as a straight line would involve errors in weight of about 10 pct.

The authors have plotted a large number of distribution curves on the scales advocated by Cerchar, with varying degrees of success. The data always show some curvature, and in many cases plotting as a straight line involves a significant sacrifice in accuracy. The reports of Cerchar contain a great number of distribution curves plotted on a probability scale, but in most cases the accuracy of the straight-line representation cannot be judged because the plotted points are not shown and no numerical data are given. Even though Cerchar advocates the use of the straight-line type of plot, it admits that no distribution data form a perfect straight line and that in many cases the deviation is serious.

If a relationship has been definitely established as being a straight line, the advantages of a straight-line plot can be realized with confidence. In the case of the distribution curve, however, so many deviations from straight-line form have been observed that it does not seem feasible to use the straight-line relationship as a basis for reducing the number

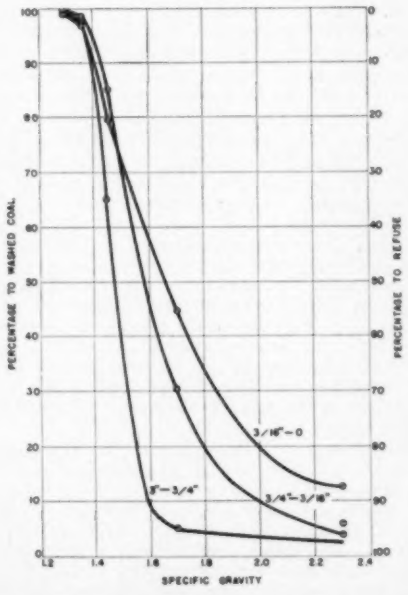

Fig. 6—Distribution curves for various sizes of coal cleaned in Baum-type jig.

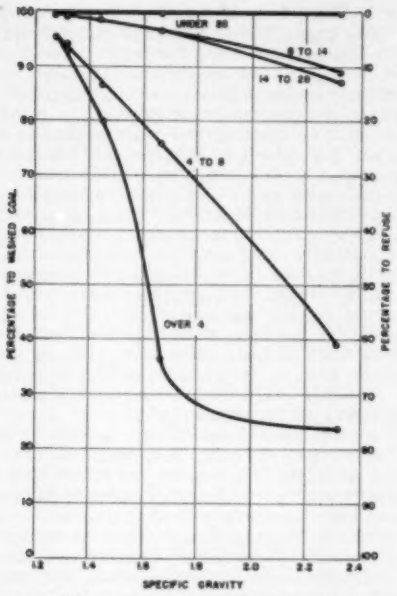

Fig. 7—Distribution curves for various sizes of coal cleaned on pneumatic table, sizes in mesh.

of densities used in performance tests. Likewise, since reliable data frequently deviate from a straight line, the relationship cannot be used to detect errors in experimental work. For these reasons, coupled with the fact that the use of a probability plot is a complication, the authors continue to plot distribution curves in arithmetic form. The arithmetic plot appears to be as useful as the straight-line form, and its greater simplicity renders it more suitable for general use in the United States.

Examination of Distribution Curve

The distribution curve and its related criteria, error area and probable error, are valuable tools, but they certainly do not represent a panacea for all the difficulties encountered in evaluating washery performance. They are subject to certain limitations which must be understood thoroughly to prevent their misuse.

One difficulty that is sometimes encountered in the use of the distribution curve is the amount of data required to fix accurately the shape and position of the curve. In American practice generally only four or five float-and-sink baths are employed in testing, and sometimes the data available for evaluating performance represent tests on only two or three densities. Occasionally the shape of the distribution curve is fixed with acceptable accuracy by only four points, but more frequently some latitude exists in drawing the curve even when five or six densities have been used in testing. The greatest difficulty in plotting the curve correctly occurs when the samples have not been tested at specific gravities higher than 1.60 and an appreciable proportion of the heaviest fraction has entered the washed product. Under these conditions it is virtually impossible to locate the curve exactly in the range of higher densities, with the result that the error area cannot be determined with complete accuracy.

European practice apparently involves the use of more and higher densities in examining samples for performance tests. Thus, American practice may have to follow the European system if distribution curves are to be more generally used. The amount of data required to give an accurate distribution curve constitutes one of the most serious limitations in the use of the curve. The same limitation applies to the efficiency formula advanced by Anderson[5] in 1950. His formula, which is the complement of the percentage of misplaced material, involves the use of a distribution curve for determining the density of separation—this being the density at which the percentage of misplaced material is calculated. To obtain comparable accuracy, use of this formula requires more data than that needed for the Fraser and Yancey formula.

Influence of Density Composition of Raw Coal: All those who have used the distribution curve have made the basic assumption that the curve was independent of the density composition of the raw coal. This assumption appears to be warranted because the method of calculating the distribution is not dependent upon the quality of the washed products. However, no data have ever been presented to show that a washing unit will yield the same distribution curve when treating coals of dissimilar density composition. Data of this type generally are not available.

The Bureau of Mines recently has undertaken an investigation in which coals of entirely different density composition will be washed in several different types of cleaning units to determine how much influence this factor has on the shape of the distribution curve. The problem is complicated by the fact that related factors such as particle shape and size composition must be comparable.

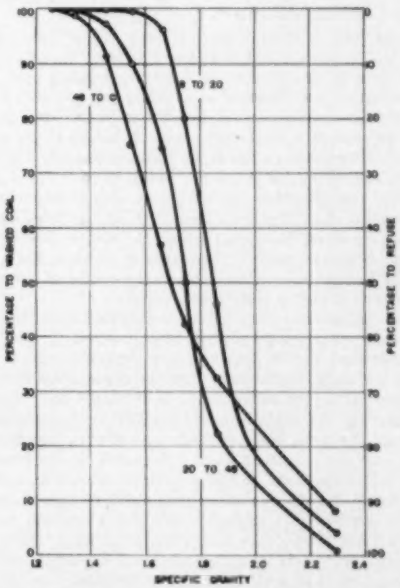

Fig. 8—Distribution curves for various sizes of coal cleaned on wet table, sizes in mesh.

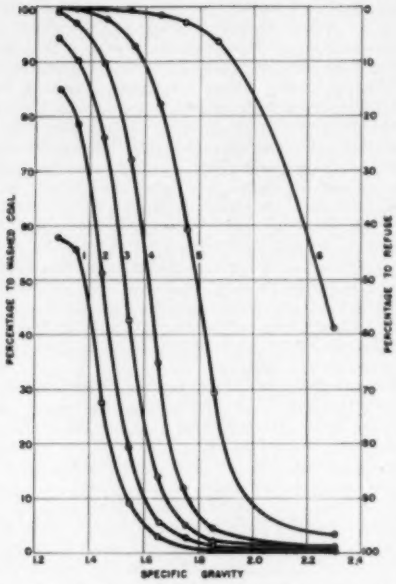

Fig. 9—Distribution curves for separations at various densities on wet table.

In this connection, it seems scarcely necessary to point out that the distribution curve no less than efficiency is influenced by such obvious factors as throughput, the mechanical condition of the washing unit, and the skill with which it is operated. Sharpness of separation is necessarily impaired by either excess feed rate or faulty operation.

Influence of Size Composition of Raw Coal: It is generally recognized that particle size modifies the influence of density in any type of cleaning unit, regardless of its mode of operation. All gravity concentrators employ currents of the separating fluid, and the size of a particle as well as its density determines its motion in the fluid. Thus, although the distribution curve for a gravity separation reflects primarily the influence of density, it cannot be entirely free from the influence of particle size as well. Even in continental European practice, where close presizing ahead of individual washing units is the rule, the influence of particle size on the shape of the distribution curve is well recognized.

The separation effected by a cleaning unit operating on a wide range of sizes is portrayed by a single distribution curve, but the performance of such a unit is shown much more completely and accurately by the family of curves that is obtained by plotting separately the distribution data for each individual size in the raw coal. Families of curves plotted in this way are shown in Figs. 6, 7, and 8 for the operation of a Baum-type jig, a pneumatic table, and a wet table. It will be observed that with each of these units the various sizes of coal were treated quite differently. Each size was separated at a different density, and each was characterized by different recoveries of coal and rejections of refuse.

Since particle size has a relatively greater influence in pneumatic units than in wet processes, the curves in Fig. 7 for the operation of the pneumatic table offer a good illustration of the importance of particle size in determining the shape of the distribution curve. The curves for the individual sizes treated in this unit indicate a marked decrease in sharpness of separation with decrease in particle size. In fact, no cleaning was accomplished in the sizes finer than 28-mesh. With the individual sizes being treated so differently, it is evident that the composite curve representing the operation as a whole is influenced directly by the proportions in which the sizes occur in the raw coal. If another coal of substantially different size composition were treated on the same table, the composite curve which would result would necessarily be substantially different from the one representing the test illustrated in Fig. 7. For example, if another coal containing twice as much material finer than 28-mesh were treated on the same table, the resulting composite curve for all sizes combined would show a separation that was distinctly less sharp.

All of the performance data studied by the authors, whether for wet, pneumatic, or heavy-medium processes, have shown the same trend in the relationship between particle size and sharpness of separation—the coarser sizes of the feed are always separated more sharply than the finer material. For wet processes the impairment in sharpness of separation with decreasing particle size is less pronounced than that observed for pneumatic units, and heavy-medium processes would be expected to show the least influence of particle size because they treat a limited range of sizes and do not depend upon currents to effect the separation between coal and impurity. However, so little detailed performance data for heavy-medium plants have been published that their performance characteristics are not well established.

A comparison of the influence of particle size in the operation of different types of washing equipment is evident in the curves of Figs. 6 and 8. In Fig. 6, representing the operation of a Baum-type jig, the distribution curves show an increase in the density of separation with decrease in particle size. This relationship between density of separation and particle size has been evident in nearly all of the performance data for jigs examined; in fact, Vissac[4] has derived an equation relating these two factors for jig operation. The distribution curves in Fig. 8 for the operation of a wet table, however, show the opposite trend. With the wet table, decreasing particle size is accompanied by decreasing density of separation. Some other data for table operation show a similar trend, and thus it may be concluded that with these

Table II. Specific-Gravity Analyses for Various Zonal Products from a Table Test, Pct

	Zone or Separation Number						
	1	2	3	4	5	6	7
Specific gravity							
Under 1.30	24.0	22.8	11.7	7.4	1.0	0.0	0.0
1.30 to 1.40	61.1	51.3	37.3	29.2	8.6	0.2	0.0
1.40 to 1.50	11.5	19.9	29.6	21.5	13.0	1.6	0.0
1.50 to 1.60	2.2	4.7	16.4	25.9	17.9	4.0	0.1
1.60 to 1.70	0.5	0.7	4.0	12.0	26.8	6.4	0.2
1.70 to 1.80	0.3	0.2	0.7	2.8	18.9	9.7	0.7
1.80 to 1.90	0.1	0.1	0.2	0.7	8.5	14.3	1.3
Over 1.90	0.3	0.3	0.1	0.5	5.3	63.8	97.7
Weight in zone, pct	31.0	15.0	10.6	8.4	8.5	13.1	13.4
Yield of washed coal, pct	31.0	46.0	56.6	65.0	73.5	86.6	

Table III. Relation of Performance Criteria for Various Separations on a Wet Table

Criterion	Separation No. 1	2	3	4	5	6
Yield of washed coal, pct	31.0	46.0	56.6	65.0	73.5	86.6
Ash in washed coal, pct[a,b]	6.4	7.3	8.6	9.8	12.4	19.6
Ash in refuse, pct[a]	30.4	44.0	51.8	59.8	69.6	76.7
Efficiency, pct	57.0	78.4	88.3	95.6	98.0	99.0
Misplaced material, pct	24.3	16.7	11.2	6.3	4.4	
Specific gravity of separation	1.38	1.45	1.53	1.62	1.78	2.24
±0.10 sp gr, pct	57.5	27.6	16.9	11.4	0.7	
Error area	55	52	52	51	63	62
Probable error		0.080	0.075	0.070	0.075	

[a] Moisture-free basis.
[b] Ash content of raw coal, 27.3 pct.

two types of washing equipment the relationship between density of separation and particle size often is reversed. Distribution curves provide interesting comparisons such as this, which frequently are obscured when performance is evaluated in terms of ash content.

Influence of Density of Separation: Much of the usefulness of the distribution curve, and its related criteria error area and probable error, naturally depends upon the extent to which it is independent of the density of separation. In many cases it is desirable to compare the performance of washing units operating at different densities, or to project the known performance of a unit working at one density to the performance that may be expected when it is operated at a different density.

Most of those who have used distribution curves in evaluating washery performance have contended that the same washing unit will have different distribution curves when operated at different densities. Vissac,[14] Tromp,[15] and Cerchar appear to be agreed on this point; all of them have stated that probable error increases with increase in the density of separation. The authors, however, have felt that the distribution curve should be substantially independent of the density of separation, at least for densities within the range in which washing equipment usually is operated. None of the investigators mentioned above who contend that probable error increases with increase in density of separation have presented any data to demonstrate the relationship, except Vissac, whose data were not free from the influence of particle size. Vissac cited data showing that with the various sizes of coal treated in a jig handling an unsized feed the separations made at higher densities were characterized by greater probable errors. However, the separations made at the higher densities were those made on the finer sizes of the feed, and thus, particle size probably had more influence on the probable error than did density of separation.

To obtain data that would serve to clarify the question of whether probable error increases with increase in density of separation, a test was made on 3/32-in. to 0 coal from the Great Falls field, Montana, using a 4-ft laboratory wet table. The discharge of the table was sampled as seven zones, numbered from one to seven with successive increase in distance from the head-motion end of the table. Specific-gravity analyses were made on the individual zonal samples, using seven baths in the range from 1.30 to 1.90 sp gr. A table lends itself particularly well to an investigation of this type, because with a single test the data for the individual zones can be added together in a number of combinations to provide separations at various densities. That is, Zone 1 can be considered the washed coal, with Zones 2 through 7 constituting the refuse, or Zones 1 and 2 can be considered the washed coal and the remaining zones the refuse; with seven zones, six different separations are possible.

Table II gives specific-gravity analyses of the individual zones, and the weight recovered in each zone. The distribution curves plotted from these data by assuming the six different successive separations are shown in Fig. 9.

Table III provides a comparison between the various criteria that may be employed to characterize the performance of the table at the six different densities of separation. The inclusion of successive zones as washed coal increased the yield of this product from 31 to 86.6 pct, with a corresponding increase in the ash content from 6.4 to 19.6 pct. The separations obtained ranged from 1.38 to 2.24 sp gr, but both probable error and error area remained practically constant.

Separations one, two, and six do not represent normal washing practice; the yield of washed coal was abnormally low for separations one and two, and in separation six not enough of the heavy impurity was removed. Hence, the distribution curves for these three separations are not the type normally encountered, and the corresponding error areas are of questionable significance. Tromp[15] contends that error area is not a valid criterion to employ unless both ends of the distribution curve approach the 0 axis closely, and this contention appears justified. Thus, the relationship between probable error, error

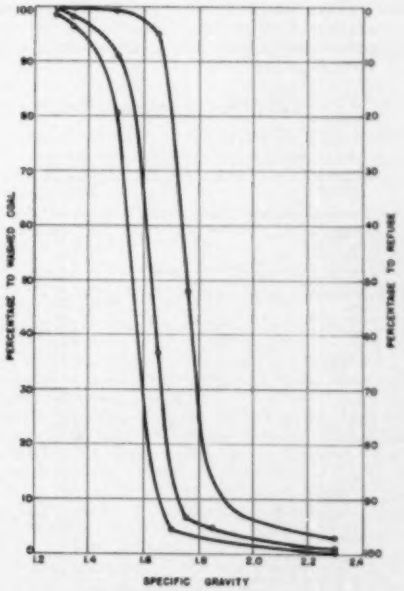

Fig. 10—Distribution curves for separations at different densities in Driessen cyclone.

area, and density of separation shown in Table III for separations one, two, and six probably should be regarded as of uncertain meaning. However, the distribution curves for separations three, four, and five represent types normally encountered, and the relationship between the various criteria for these separations is valid. Thus, on the basis of this table test, both error area and probable error can be regarded as being substantially independent of the density of separation in the range of separating densities at which coal-washing equipment generally is operated.

A similar conclusion can be drawn from the distribution curves shown in Fig. 10 for the operation of a Driessen cyclone as a heavy-medium cleaning unit. In the three tests represented by these curves, successively higher densities of separations were obtained by removing smaller proportions of refuse. The three curves are parallel, straight lines through the range of 75 to 25 pct recovery in the clean coal, and hence the probable error for all three separations is the same. Similarly, the error area for the separations, which were made at specific gravities of 1.56, 1.63, and 1.75, were 37, 41, and 43, respectively. Variations in error area of this magnitude are scarcely significant, and thus these tests, like the wet-table test previously described, indicate that the criteria probable error and error area are not influenced by the density of separation, at least in the usual range of separating densities.

Comparison of Criteria

Throughout the present report a distinction has been maintained between the sharpness of the separation effected by a washing unit and the efficiency of the washing operation. The two criteria are absolutely different, though sometimes confused because their relationship is not fully appreciated. For example, in "Coal Preparation,"[10] the term efficiency is used for the criteria which evaluate only sharpness of separation. This practice scarcely can be called improper in the absence of any rigid standardization of terminology. Nevertheless, current usage by Cerchar, Tromp, Driessen, Vissac, and others who are employing the concept of sharpness of separation preserves a distinction between it and efficiency. American practice should be no less discriminating.

Examination of the data in Table III, which summarizes the performance of the wet table, will clarify the influence of sharpness of separation on the more familiar criterion, efficiency. The efficiencies of the various separations made on the table ranged from 57.0 to 99.0 pct, even though the sharpness of separation—as measured by either error area or probable error—remained practically constant. Progressive increase in the density of separation was accompanied by a progressive increase in efficiency. Thus, equally sharp separations may provide entirely different efficiencies, depending upon the densities at which they are made.

The data in Table III show that as the specific gravity of separation increased there was less material within the limits of ±0.10 of this specific gravity. This decrease in the amount of material close to the density of separation generally has been regarded as being responsible for the improved efficiencies obtainable with separations at higher densities. Such a contention seems reasonable, since it is the material within ±0.10 of the specific gravity of separation that is treated with the least degree of sharpness. However, as stressed by Cerchar, the mix-up of material that occurs near the density of separation results in trading a small amount of material that should have been recovered in the clean coal for an equal amount of material that should have been rejected as refuse. These two groups of material differ little in ash content, and hence their improper distribution does not change the yield and usually has only a minor effect on the ash content of the clean coal; similarly it does not result in a great loss in efficiency.

Efficiency is influenced to a much greater extent by the recovery effected in the lower density range, for the loss of a few percent of this material gen-

Table IV. Comparison of Performance Criteria for a Number of Washing Operations

Cleaning Unit	Size of Coal, Inches or Mesh	Specific Gravity of Separation[a]	±0.10[b]	Error Area	Probable Error	Misplaced Material, Pct	Efficiency,[c] Pct
Heavy medium	Over ¼	1.56	7.0	6	0.011	1.4	
Heavy medium[d]	1¼ to ¾	1.80	4.8	24	0.031	0.7	99.9
Heavy medium[d]	2 to ¼	1.57	22.5	28	0.040	5.8	97.1
Heavy medium	1⅝ to 15/16	1.79	20.3	48	0.074	3.5	
Heavy medium[d,e]	14 to 35	1.63	1.7	24	0.044	0.4	99.9
Heavy medium[d,e]	8 to 200	1.65	10.4	28	0.027	3.0	98.5
Jig, Baum	5 to 0	1.57	7.0	63	0.087	4.8	97.5
Jig, Baum	5 to 0	1.46	14.4	68	0.111	21.0	72.3
Jig, Baum	3 to 0	1.67	10.0	76	0.086	8.7	96.1
Jig, Baum	3 to 0	1.53	5.8	81	0.103	3.4	98.0
Jig, pulsator	3 to 1¼	1.45	19.8	57	0.057	7.9	94.0
Jig, pulsator	1¼ to ¼	1.70	2.3	95	0.130	2.2	99.6
Jig, plunger	1¼ to 0	1.63	4.3	78	0.088	6.0	97.3
Jig, basket	1 to 0	1.72	4.9	93	0.130	4.5	97.8
Wet table[d]	3/32 to 0	1.78	6.7	63	0.075	4.4	98.0
Wet table[d]	¼ to 0	1.70	1.9	79	0.103	2.5	99.3
Rheolaveur	4 to 5/16	1.63	10.4	75	0.096	8.5	98.8
Rheolaveur	5/16 to 0	1.70	13.5	130	0.294	7.1	94.4
Menzies cone	3 to 2	1.55	8.7	31	0.035	2.9	99.3
Menzies cone	¾ to ⅜	1.65	3.8	63	0.078	2.5	98.2
Hydrotator	11/16 to 28	1.83	4.2	63	0.099	2.6	99.0
Froth flotation	16 to 0	1.57	3.6	75	0.127	4.3	99.2
Froth flotation	10 to 0	1.68	4.7	125	0.234	7.2	96.4
Humphreys spiral[d]	8 to 0	2.04		147	0.367		91.8
Pneumatic table[d]	⅛ to ¼	1.68	2.0	94	0.131	3.2	98.3
Contraflow	2 to 0	1.79	1.8	98	0.179	3.0	99.2

[a] The specific gravity at which the distribution curve crosses the 50 pct ordinate, indicating equal distribution of material between washed coal and refuse.
[b] Not adjusted for material heavier than 2.0 sp gr.
[c] Fraser and Yancey formula: yield of washed coal divided by yield of float coal of some ash content.
[d] Laboratory test, all others plant tests.
[e] Cyclone.

erally results in a corresponding loss in efficiency. Examination of the distribution curves in both Figs. 9 and 10 demonstrates that with separations at higher densities the recovery of the lighter fractions of coal is improved, and this higher recovery is primarily responsible for the better efficiencies that are obtained in separations at higher densities. This condition applies to all but some heavy-medium operations.

The great influence that the recovery effected in the range of lower density has on efficiency directs attention to an important practical limitation in the use of error area as a criterion of washery performance. The error area representing the loss of the light coal is only a small part of the total, and yet this portion of the area exerts the most influence on efficiency. In one instance, for example, an increase in error area from 81 to 85 resulted in a loss in efficiency of over 6 pct because the increase in error area was entirely in the range of lower density. The same numerical increase in error area at either intermediate or high density would have decreased the efficiency only 1 pct. The common practice of expressing error area as a single figure has been followed in this report for the sake of simplicity, but the use of two separate areas representing the inclusion of impurity in the washed coal and the loss of coal in the refuse provides a measure of performance that can be correlated better with efficiency.

This limitation in the usefulness of error area should not be construed as presenting an advantage of probable error over error area, for probable error does not even take into account directly what recovery was effected in the lightest coal or what proportion of the heaviest impurity was rejected as refuse.

Table IV summarizes the results of 26 washing operations in terms of density of separation, efficiency, percentage of misplaced material, error area, and probable error. These data demonstrate clearly that there is no direct correlation between efficiency and misplaced material on the one hand and error area and probable error on the other. A sharp separation is an efficient one when made on a coal of favorable washability characteristics, but even a very sharp separation may result in a relatively low efficiency if made at a low density or if the coal contains an abnormal amount of material of intermediate density.

Summary

One of the principal objectives of the First International Conferences on Coal Preparation held in Paris in June, 1950, was to promote international standardization of the methods used for evaluating coal-washery performance.

Performance can be evaluated in a number of different ways, with the choice of the proper method to use being dictated by the objectives of the investigation and the data available. The performance of any cleaning unit is determined by the character of the raw coal treated, the density of the separation, and the sharpness of the separation effected between coal and impurity. Thus, three factors enter into performance; one is determined by the coal, one is dictated by market or use considerations, and one is an inherent characteristic of the cleaning unit itself.

Efficiency, which is influenced by all three factors, measures directly the loss of salable coal and thus is the performance criterion of greatest practical value.

Sharpness of separation is measured in terms of either error area or probable error, both of which are determined from a distribution curve for the washing operation. These criteria are useful in comparing the operation of washing units making dissimilar separations, because they are substantially independent of either the character of the raw coal or the density of separation. They must not be confused with efficiency, however, because low values of error area or probable error sometimes are accompanied by low efficiency.

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A Calorimetric Method for Studying Grinding in a Tumbling Medium

by A. Kenneth Schellinger

DURING the comminution of a brittle material in the presence of dry air, no known phase change or chemical reaction takes place. The energy changes associated with the comminution are those of the transformation of kinetic energy into heat energy and the energy absorption represented by the actual rupture of molecular and/or ionic bonds. The random nature of the actual grinding process in a tumbling-mill often precludes the effective application of a rupture force on each individual particle of brittle mineral present. The result must be a great deal of useless vibration on an atomic scale in both the brittle mineral and the grinding medium below the elastic limit, which vibration is eventually manifested as heat energy in the mill. The actual rupture of molecular, or ionic, bonds creates new surface on the brittle minerals; each square centimeter of this new surface then must possess a number of potential bonds, each of which could reform theoretically with the release of energy. The sum total of this potential energy of bonding per unit of new surface, minus bond satiation effects of the enclosing gas or liquid, must be the surface energy of the mineral. If the comminution of the brittle mineral were carried out within the chamber of a calorimeter, the energy released as heat could be determined rather accurately. Moreover, the total kinetic energy input to the comminuting mass (mineral and medium) conceivably could be derived by a suitable torquemeter and revolution counter if the whole calorimeter were revolved. The difference between these two energy figures should then represent the net energy (gross energy input—heat energy output) used in creating new surface, gliding or slip on atomic planes, twinning, and possibly other lattice rearrangements within the mineral. If it be postulated further that with a hard, brittle crystalline material, such as quartz, the energy used to produce gliding, twinning, and other permanent lattice movements is a very small fraction of the total net energy absorbed, then this energy absorption within the grinding calorimeter can be ascribed to the creation of new surface energy alone. Such energy is, from the thermodynamic standpoint, the true effective work of the grinding device, in this case a tumbling-medium mill. The ratio of this effective work (in calories) to the total energy input (in calories) should express the thermodynamic efficiency of the comminution taking place under the conditions used in the grinding calorimeter.

This approach to the measurement of the energetics of tumbling-mill grinding was suggested by some previous work by Fahrenwald and coworkers[1] with a laboratory ball mill and a thermometer. They measured the efficiency of grinding based on the formula:

$$\text{Pct Grinding Efficiency} = \frac{\text{Energy (calories) Input} - \text{Thermal Energy Output (calories)} \times 100}{\text{Energy input (calories)}}$$

Efficiencies thus measured, while grinding quartz sand, ranged from 19.7 pct to 7.4 pct. Cook in 1915,[2] used this approach to the problem of grinding efficiencies in stamp batteries and obtained the energy input by stamp weights times drop distances and the energy output by means of thermometers and pulp flow rates. He calculated that 80 pct of the input energy to the stamp shoes was wasted as sensible heat in the ore pulp. No other studies of comminution by this method of energy differences came to the author's attention.

Reasonable agreement as to the order-of-magnitude of comminution efficiencies in tumbling-media mills is lacking in the literature. There is a widespread impression among technical workers that the grinding efficiency of the industrial ball mill may be on the order of 1 pct, or even a fraction

Table I. Calibration of the Grinding Calorimeter-Energy Balances without Brittle Charge

Run No.	Chamber Charge	Gram-calories Input	Output	Diff.	Input, Pct
2	(dry) steel balls	440	430	−10	−2.3
3	(dry) balls	298	296	−2	−0.7
5	(dry) balls	407	408	+1	+0.2
14	Chilled C.I. shot (dry)	1260	1255	−5	−0.4
33	Chilled C.I. shot (wet)	1455	1455	0	0
3B	Chilled C.I. shot (dry)	1375	1380	+5	+0.4
5A	Chilled C.I. shot (dry)	1410	1393	−17	−1.2
1A	Chilled C.I. shot (dry)	1405	1420	+15	+1.1
9SC	Chilled C.I. shot (dry)	1228	1220	−8	−0.6
11SA	Chilled C.I. shot (dry)	1358	1340	−18	−1.3
9SB	Chilled C.I. shot (dry)	964	963	−1	−0.1
		Input, avg pct:			−0.45

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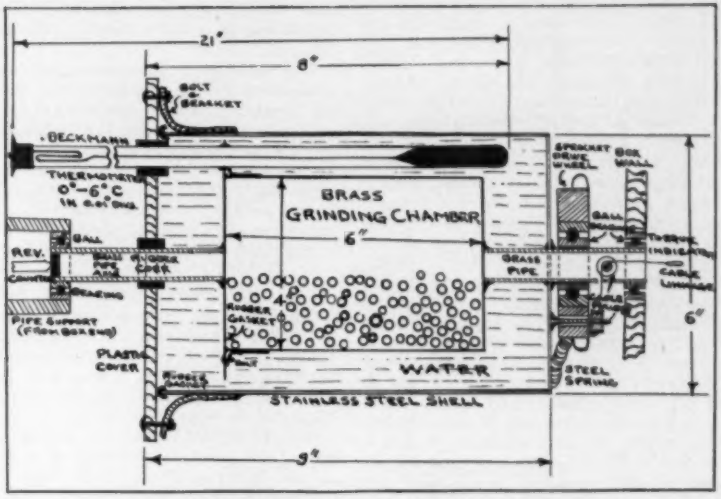

Fig. 1—Grinding calorimeter, longitudinal section.

of this. Values calculated from theoretical surface energy figures for quartz (Edser's value of 920 ergs per sq cm, and Martin's value of 520 ergs per sq cm) plus the surface areas of ground products have tended to be less than 1 pct. Johnson, Axelson, and Piret,[3] working on quartz, with drop-weight crushers and gas-adsorption surface area measurement have concluded that the efficiency of crushing is of this order of magnitude, 0.1 pct, if the theoretical surface energy figures are correct. However, Gross and Zimmerly[4] found the surface production efficiency of ore-grinding ball mills to be about 45 pct. Wilson[5] obtained similar efficiency figures ranging from 19 to 43 pct for ball mills grinding cement clinker. Bond and Maxson[6] found efficiencies in the neighborhood of 60 pct during the grinding of various ores in connection with their standard grindability test. All of these workers avoided acceptance of theoretical surface energy values by use of the drop-weight crusher, or a similar device, as a standard of comparison. In effect, then, surface energy figures obtained by the use of the drop-weight crusher plus several methods of estimating the new surface produced, have been used to show that the ball mill is from 20 to 60 pct efficient as a surface producer. Theoretical surface energy figures for quartz, on the other hand, have condemned the commercial ball mill to the unenviable category of better than 99 pct efficiency as a heat energy producer.

Calorimeter Construction

Construction of a calorimeter to embody the principles and objectives outlined meant that a suitable grinding chamber had to be enclosed completely in the calorimetric fluid—water in this case. To impart a tumbling action to the contained grinding medium, the chamber was designed as a 6x4 in. cylinder turning on its long axis in a horizontal position. This was the tumbling-mill portion of the calorimeter. The calorimeter is shown in Fig. 1. The energy output from the grinding chamber was readily measurable with this calorimetric assembly to a good degree of accuracy.

However, to derive the input energy with an equal degree of accuracy meant the construction of a suitable torquemeter that could record the net turning torque exerted on the tumbling medium at all times. Frictional torque was essentially zero, inasmuch as the calorimetric assembly, when filled with water but with no grinding medium (shot), could be spun easily on its ball bearings. Experimentation with dc motor efficiencies and other methods, convinced the author that sufficient accuracy could not be obtained in this direction. The device finally decided upon was modified from one described by Gross and Zimmerly[7] to determine work input to a laboratory ball mill. The modified device consisted of a sprocket wheel fitted to the calorimeter closed-end axis, shown in Fig. 1, by means of a ball-bearing race, so that it revolved freely in relation to the axis. Driving torque was transmitted to the calorimeter proper by means of a steel spring fastened tangentially between this sprocket wheel and the bottom of the water jacket. Increased turning torque meant increased spring extension, which was transmitted to an outside recorder by means of a taut cable system. This recording torquemeter system is shown in Fig. 2.

The entire assembly was enclosed in a wooden box with a glass cover to permit control of thermal losses from the water jacket shell. Some details of this enclosure are shown in Fig. 2. Calorimetric thermometers were inserted through the top of the box so that the air temperature on each side of the

Table II. Preliminary Load-Efficiency Data for Dry and Wet Grinding in the Grinding Calorimeter

Charge	100		200		300		400	
Quarts, g	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Energy, grinding calorimeter								
Input	1207	1168	1100	1248	1345	1270	1215	1230
Output	1092	1020	927	1080	1080	1025	1080	1130
Net (to new surface)	115	165	173	198	255	245	135	100
Efficiency, pct	9.7	13.9	15.7	15.9	19.0	19.3	11.1	8.1
Product —325-mesh, g	14.7	39.6	32.6	33.4	46.5	39.3	42.8	44.4
Charge, pct	14.8	39.6	16.3	16.7	15.5	13.1	10.7	11.1

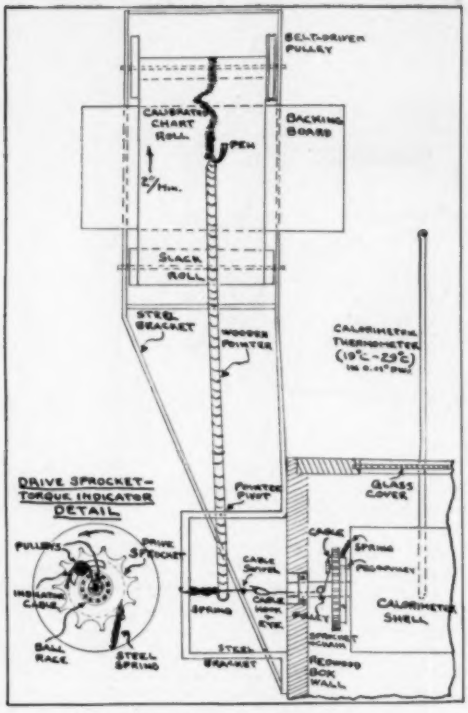

Fig. 2—Recording torquemeter assembly.

calorimeter shell was known. These thermometers were read to 0.01°C. A small fan driven by a stirrer motor was inserted in each side of the box to keep the air within thoroughly mixed. A sensitive thermo-regulator also was hung within the box beside one of the calorimetric thermometers. This controlled a solenoid air valve which, in turn, supplied the box with cold compressed air from a copper coil submerged in an ice bath. By this means the air temperature around the calorimeter could be held at any desired figure between 25° and 15°C, to within 0.1°C by adjusting the thermoregulator. Thus thermal potential between the calorimeter water and the outside air could be set to any convenient figure. Curves were then drawn up by plotting thermal leakage (degrees per minute) against thermal potential; one curve was for the calorimeter shell while stationary and another while revolving at about 70 rpm. The completed box-calorimeter assembly required careful calibration before use in actual grinding studies.

Instrument Calibration

Calibration of the assembled instrument was accomplished by evaluation of the following:

1—The calorimeter constant in terms of calories per hundredth of a degree centrigrade temperature rise on the Beckmann thermometer.

2—The value of the scale on the recording torquemeter chart in terms of foot-pounds of energy per revolution of the calorimeter.

In addition, balances of input energy against output energy were made when no useful work was done in the grinding chamber, that is, when no brittle material was present. These are reported in Table I.

The calorimeter constant, 29.6, was derived by releasing a known amount of heat within the grinding chamber under conditions of temperature equilibrium and noting the resultant temperature rise on the Beckmann thermometer. Torque values in foot-pounds per revolution were translated to recording torquemeter scale values by hoisting a known weight through a definite distance and allowing the resulting pointer deflections to mark on the torquemeter chart.

Preliminary Experimental Results

The grinding calorimeter comminutes brittle solids in much the same manner as does a large industrial ball mill; that is, by enveloping small particles of the solid in a tumbling mass of larger spherical grinding medium where compressive and frictional stresses tend to rupture the brittle material. Therefore it was thought that an investigation of the absolute efficiency of surface production in the calorimeter might be more directly comparable to large-scale practice than would an investigation by means of drop-weight crushers or other devices. Control of many but not all of the variables found in large-scale tumbling-mills is possible in the calorimeter. These include relative weights of charge and grinding medium, shape and size distribution of grinding medium, speed of rotation, grinding fluid, pulp density, and others. Major disadvantages in a direct comparison with large-scale grinding are the impossibility of reproducing the particle-ball contact intensity factor and the necessity of using a batch grinding technique.

Loading and the Thermodynamic Efficiency: Preliminary experimental work was concerned with discovering the most efficient loading of the mill with brittle material, for it was found early in the work that the loading factor had a large influence on the grinding efficiency. Technique consisted of varying the weight of brittle charge, while holding the other factors such as speed, kind of grinding medium, weight of grinding medium, etc., constant. For each weight of charge the difference between input and output energy was determined by a standard experimental procedure and the grinding efficiency was computed by the relation:

$$\text{Pct thermodynamic grinding efficiency} = \frac{\text{(Input) (energy)} - \text{(Output) (energy)}}{\text{(input energy)}} \times 100$$

This was done with a dry charge over a range of weight values, and then over the same range with the charge mixed with water in the ratio 60 charge: 40 water, or 60 pct solids. Hence these two sets of experimental values on the same brittle mineral formed a comparison of the energy efficiencies of dry and wet grinding under otherwise similar conditions.

The brittle mineral used was a glass sand composed almost entirely of rounded quartz grains and was screened to give grains ranging in size between 100 and 200-mesh. That is, the approximate average grain diameter of the quartz charge was 0.0044 in. The average diameter of the chilled shot charge was approximately 0.185 in., which would give a ball:charge diam ratio of about 42. This might correspond to a ball mill using a 3-in. grinding ball to

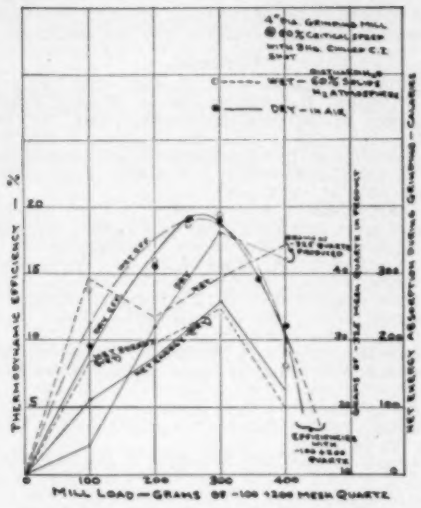
WET – 60% SOLIDS
DRY – IN AIR
THERMODYNAMIC EFFICIENCY – %
MILL LOAD – GRAMS OF -100 +200 MESH QUARTZ
NET ENERGY ABSORPTION DURING GRINDING – CALORIES
GRAMS OF -325 MESH QUARTZ IN PRODUCT

Fig. 3—Mill loading vs. efficiency and —325-mesh in product for wet and dry grinding in the grinding calorimeter.

grind approximately 10-mesh mineral. Further, the mill:ball diam ratio for the calorimeter was 21.6, which corresponds to a 5 ft 4 in. diam ball mill using 3 in. balls as a grinding medium—admittedly a rather improbable commercial situation. The length of the grinding time for each determination was about 30 min or 2100 rev at 70 rpm, which roughly corresponds to 60 pct of the apparent critical speed of the mill as shown by the torquemeter.

Wet runs were made by the use of distilled water and tank nitrogen gas to avoid heat-producing oxidation effects. For these the grinding chamber was pumped down by means of a vacuum pump after charging with quartz and water, and the air was replaced with nitrogen. Several repetitions of this treatment gave an atmosphere within the grinding chamber that produced no noticeable oxidation of the ferrous grinding medium. A correction was made in the calorimetric constant to allow for the water in the grinding chamber.

After each run the grinding chamber was opened and the quartz charge screened on a —325-mesh Tyler sieve to provide an approximate indication of the amount of surface produced. The charge had no —325-mesh material prior to grinding. Wet ground material was washed from the grinding chamber and shot medium by means of alcohol to inhibit rusting of the shot. Data collected during these dry and wet efficiency runs are presented in Table II and also in Fig. 3 where the plotted efficiency data trends are averaged by means of smooth parabolic curves.

Fig. 3 indicates that the thermodynamic efficiencies during both wet and dry grinding of quartz sand in the calorimeter range from 10 pct to 19 pct and are dependent on the loading of the grinding chamber. The most efficient loading of the grinding chamber appears to be near 300 g, with efficiencies dropping off on each side of this peak in a parabolic fashion. The efficiency-load curves for both wet and dry grinding show no significant differences, which is somewhat unexpected inasmuch as wet grinding is generally regarded as more efficient than dry grinding. It must be remembered, however, that the plotted thermodynamic efficiencies are for surface production rather than for a certain weight per kw-hr finer than a chosen mesh size. The total grams of —325-mesh quartz produced in each case is a very rough measure of the new surface production and is seen to follow the efficiency curves approximately when plotted on Fig. 3.

Pulp Density and Thermodynamic Grinding Efficiency: A number of runs were made with a constant solids charge of 250 g of quartz sand ranging in size between 100 and 200-mesh. The variable employed was the degree of wetness of the charge, that is, the quantity of water was varied from 800 to 0 g corresponding to pulp densities of 30, 40, 60, 80, and 100 pct solids. Corrections then were applied to the calorimeter constant to allow for the heat capacities of these varying amounts of water in the charge. All other variables were held constant except the charge level in the grinding chamber which rose with dilution.

Results of these runs are shown in Fig. 4. Efficiency is seen to have a downward trend towards the pure water end as might be expected. This trend is small in the practical grinding range, for efficiencies drop only from 18.5 pct at 100 pct solids (dry grinding) to 14.5 pct at 30 pct solids. Such a variation is probably within the experimental error inherent in this first model of the calorimeter and is contradicted somewhat by the comparison shown in Fig. 3.

Summary and Conclusions

1—A calorimetric technique has been developed for investigating the small-scale comminution of brittle minerals by the tumbling-mill principle.

(a) Construction of a revolving grinding calorimeter is described wherein a brittle mineral is ground by tumbling cast-iron shot in a 4-in. diam brass grinding chamber totally enclosed in a water jacket.

(b) Calibration and use of the calorimeter is described. When properly calibrated, the instrument will give a balance between input energy and output energy without brittle mineral in the grinding chamber.

2—Preliminary experimental runs with the grinding calorimeter on —100 +200-mesh quartz sand have yielded the following results:

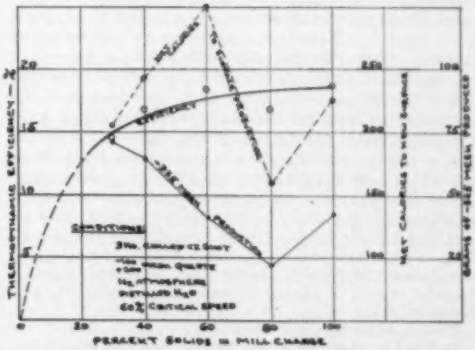

Fig. 4—Pulp density vs. efficiency and —325-mesh in product.

(a) That the absolute thermodynamic efficiency of surface production in the grinding chamber is a function of mineral quantity, of pulp density, and possibly of a number of other variables.

(b) That during dry grinding and during wet grinding at 60 pct solids, the thermodynamic efficiencies shown by the instrument varied from 10 to 19 pct, with the higher figure occurring at an optimum loading of 270 g of quartz sand.

(c) That there was no significant difference in peak efficiency between dry and wet grinding under the given conditions, i.e., 60 pct solids, 60 pct critical speed, −100 +200-mesh quartz.

(d) That the efficiency curve dropped slightly with increasing dilution of the charge with water, i.e., from 19 pct at 100 pct solids to 14.5 pct at 30 pct solids.

3—The establishment of an order-of-magnitude calorimetric value for the thermodynamic efficiency of the tumbling-mill type of grinding is regarded as one of the most significant results of the research. The optimum value found, 19 pct, agrees qualitatively with values found by earlier investigators using thermal methods on laboratory mills and is about 50 pct of the value found by Gross and Zimmerly for commercial ore-grinding ball mills.

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Technical Note

Beaker Flotation as a Quantitative Tool in Flotation Testing

by William Loblowitz

A simplified system of flotation testing has been developed recently at the Bureau of Mineral Research of Rutgers University. The technique involves the known principle of skin flotation and can be used with minute quantities of sample and reagents in a beaker. A vessel containing the conditioned sample with added water and flotation reagents is held inclined and rotated slowly. Water-repellent particles come in contact with air and float on the surface of the liquid, while wettable particles are submerged. The float is poured off and filtered whereas the nonfloat remains in the beaker. The filtrate may be returned to repeat the process.

This procedure can be made quantitative. Separations are obtained and are remarkably complete and repeatable. The effect of different reagents, optimum quantities, pH and other variables can be determined in a fraction of the time required for conventional testing. However, the method gives no information on the effect of frothers and the quality of froth to be expected in a cell, and it is not practical for particles finer than 200-mesh. Unlike other preliminary tests, separate float and nonfloat products are obtained, and their contents can be determined quantitatively by chemical analysis or grain counts. After the optimum reagent combination has been determined, the effect of fines and frothing may be verified in the conventional flotation cell. On the other hand, agglomeration-tabling can be directly duplicated from beaker tests.

Procedure: Five to ten grams of sample are weighed into a 100-ml beaker. Flotation reagents and a small initial quantity of water are stirred together; additional water is then added to produce the proper water-solids ratio. The beaker is then tilted to 45° and rotated slowly. After three to five rotations, liquid and float are poured off and filtered; the filtrate may be recycled until the separation is completed.

One test generally requires less than 10 min. Reagent concentration and pH remain quite constant because of the recycling of the filtrate. Two to four tests may be made simultaneously, and the effect of varied conditions may be observed by comparison. Considerable time is saved in preparation and handling since small quantities of sample suffice for a series of systematic tests.

Repeatability

One test was repeated four times under constant conditions. The sample used was a quartz sand containing approximately 24 pct feldspar and some clay aggregates. The +28-mesh grains had been screened out, and most of those finer than 100-mesh had been removed by hydraulic classification. The results are presented in Table I.

For comparison, 500 g of the sample were separated by agglomeration-tabling using the same reagent combination and quantities as given in Table I. The weight percent float was 18.3 pct, composed almost entirely of feldspar and with only traces of quartz. Most of the remaining feldspar was recovered in a middling product with 2.2 pct by weight.

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Table I. Flotation Test on Quartz Sample

Test Number	1	2	3	4	Avg	Avg Deviation
pH at start	3.15	3.25	3.20	3.18	3.19	0.04
pH at end	3.20	3.28	3.25	3.22	3.24	0.03
Weight pct float	20.65	20.25	21.20	21.15	20.81	0.38
Quartz in nonfloat,* pct	98.8	98.0	97.4	97.2	97.4	0.35

(Grain count: only +80-mesh grains counted)
Reagents: Hydrochloric Acid 3.3 lb per ton
Sodium Fluoride 1.1 lb per ton
Armac CD 0.17 lb per ton
Fuel Oil 5.5 lb per ton
Float removed by pouring six times.
*Float products contained over 98 pct feldspar, some clay aggregates and few fine quartz grains.

The nonfloat contained over 98.5 pct quartz as determined by grain count. This separation agrees well with the results obtained by beaker-flotation.

Other tests were made on the classifier overflow product of the same quartz sand that contained 90 pct −100-mesh and 23 pct −200-mesh. No effective separation was obtained. After screening out the −200-mesh particles, however, separations of quartz and feldspar equivalent to those in a flotation cell were obtained. For tests in the range of 100 to 200-mesh, 5 g samples were used, and the decanting of the float had to be repeated 16 times to achieve complete separation.

Mechanical Rotation

To reduce the human factor in rotating the beaker, it was found convenient to use a laboratory motor turned upside down so that its shaft points upward at an inclination of approximately 45°. Instead of the shaft, a short bolt is inserted into the chuck. A clamp grips the 100-ml beaker, which may be rotated at the desired inclination by running the motor at low speed. The motor is mounted on a laboratory support above a filter funnel, so that the beaker may be emptied into the filter by tilting the motor. Motor and beaker are then returned to the 45° position and the filtrate is returned to the beaker to repeat the separation cycle. This apparatus is not essential for the application of the method.

Field Testing

By using this method a rapid flotation test may be performed in the field far from the laboratory. Equipment would include a small mortar and pestle, two 2-in. diam sieves, beaker, funnel, filter paper, and reagent solutions in dropper bottles.

Summary and Conclusions

1—A rapid quantitative method for testing minerals by "skin" flotation was established.

2—Only 5 to 10 g of sample and no complicated equipment are required.

3—Particle size limits are 10 to 200-mesh.

4—Tests were reproduced with an accuracy comparable to careful testing with a laboratory flotation cell; the average deviation was 0.38 pct for four parallel tests.

5—The method may be used in the field with simple equipment.

6—A device for mechanical rotation and tilting is described but is not essential to the test.

Acknowledgment

Thanks are due to J. H. C. Martens for his friendly cooperation in performing the grain counts and to Helgi Johnson for editing this paper.

Technical Note

Approximation of the Energy Efficiencies of Commercial Ball Mills by the Energy Balance Method

by A. Kenneth Schellinger and Rustam D. Lalkaka

IF the ball mill is considered only from an energy standpoint, it can be thought of as a converter of kinetic energy into heat energy and surface energy. The law of the conservation of energy must apply to the ball mill as it does to any machine or process in nature. The heat energy output of the ball mill is apparent to any casual observer of the operating mill since the outflow pulp will be appreciably warmer than the inflow water and rock. The rock in the ball mill is crushed by shearing of its ionic bonding caused by some impact-induced stresses beyond the elastic limit. As the bonds holding the mineral crystal lattices together are ruptured, new surface area is created on each unit of which a definite number of unsaturated bonds exist. Such unsaturated energy of bonding may be termed the "surface energy," and is a potential energy figure. This created energy was withdrawn from the ball mill system and represents an absorption, or disappearance of heat. To reduce the size of the rock, surface area must be created and with it the attendant characteristic surface energies of the minerals concerned. Thus the creation of surface energy, from an energy viewpoint, is the creation of useful work by the ball mill.

Because of the controversial nature of the energy efficiency figures for modern operating ball mills, it seemed worthwhile to approximate the ordinary magnitude of such efficiencies from the above viewpoint. This was done by an energy balance of the three aforementioned forms of energy, kinetic, heat, and surface energy, for two 9½x10-ft grate-type ball mills grinding cement raw materials. Kinetic energy input to the balls was approximated as closely as possible while the heat energy output was measured by means of a thermometer and water and rock flow rates. The assumption was made

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Table I. Data for Energy Balance Approximations

	Primary No. 1 Run 1	Primary No. 1 Run 2	Primary No. 2 Run 1
Feed, tons per hr	64	70	60
Outflow, pct solids	68.5	69.5	56.0
Power input, hp	480	526	445
Temperatures, °C			
Rock input	21.8	22.3	22.2
Water input	24.0	27.8	27.8
Pulp outflow	28.9	31.9	30.0

that the low noise level represented a negligible amount of energy as did any phase changes, oxidation effects, etc. in the rock mass. These considerations led to the energy efficiency approximation formula:

$$\text{Pct energy efficiency} = \frac{\text{kinetic energy input (calories)} - \text{thermal energy output (calories)}}{\text{kinetic energy input (calories)}} \times 100$$

Measurement of energy efficiencies of a small tumbling-medium mill has been made by Fahrenwald[1] and coworkers. These efficiencies, during the grinding of quartz, varied between 7 and 19 pct. A grinding calorimeter, using the tumbling-medium principle, has been used by one of the authors[2] to obtain energy efficiency figures in the range 10 to 19 pct while grinding quartz sand. Application of the method to large operating grinding mills has not been reported in the literature, although Cook[3] long ago applied it to an operating stamp battery and showed that over 80 pct of the input energy to the stamp shoes was degraded as heat energy.

Method and Data: Energy approximations for the purpose of computing balances on operating mills required the use of a sensitive thermometer to ascertain the temperatures of the various streams of rock, water, and pulp flowing into and from the mills. Flow rates were obtained from known operating data on the mills or were measured, if necessary. Temperature of the rock feed stream was taken by repeatedly immersing the sheathed bulb of the thermometer in the moving rock on the belt and reading the equilibrium temperatures obtained. The percentage of solids in the pulp stream leaving the mill was determined by the usual method of weighing a fixed volume of the pulp and reading the percentage of solids from a prepared chart. From this determination the tonnage of water entering the mill with the rock could be calculated. Temperature of the water was taken by immersing the thermometer bulb in the water jet feeding into the mill feed-scoop box. The temperature of the pulp stream leaving the mill for the classifier was taken in a similar manner. Final temperature figures in each case were obtained by averaging a number of readings, each taken at a different point in the material stream concerned. Data for energy balance approximations are given in Table I.

The motor power input at the time of the temperature reading was taken from a polyphase watt-hour meter and was checked against the average power drawn during the previous 24-hr period. Variations in the power draft of the mills were quite small.

The designations and types of ball mills on which these measurements were made are as follows:

Primary No. 1 Allis-Chalmers 9½x10-ft grate-discharge ball mill, 500-hp drive motor

Primary No. 2 F. L. Smidth 9x11½-ft grate-discharge ball mill, 500-hp drive motor

The average specific heat of the rock input to the mills (approximately $CaCO_3$, 84 pct; SiO_2, 16 pct) can be calculated from well-known equations as 0.1935 at 27°C. The specific heat of water at the same temperature is 0.9976. The net energy input to the balls alone is obtained by applying a factor (0.77) to the energy input to the motor. This factor was obtained from the literature where it was found that Gow and Guggenheim[4] had packed a normal ball load around the axis of a 6x4-ft mill and had run it at 80 pct of critical speed without any ball motion in order to obtain the power loss caused by friction alone. In the absence of any direct data on larger mills this factor was used for the energy balance approximations.

Radiation and convection loss or gain by the rotating mill shells is a distinct possibility if the surrounding air temperatures differ from that of the mill shells themselves. The radiation and convection rate depends upon a number of factors such as the surface finish and shape of the shell, the temperature of the shell, and the thermal gradient between shell and air. These are complex factors to evaluate and no attempt was made to do so in these approximations when it was found that the air temperature in the neighborhood of the mill shells was substantially the same as the average temperature in the mill.

The results of calculations made by and with the foregoing methods and data are shown in Table II.

The thermodynamic efficiencies obtained by the foregoing approximations appear to confirm the few results obtained by other workers who have used this approach. Hence, Fahrenwald's[1] efficiencies, 7 to 19 pct, on a laboratory ball mill are very similar to the mill efficiencies, 19.7, 10.2 and 19.9 pct shown in Table II. Results obtained with the grinding[2] calorimeter (10 to 19 pct) are also in the same range as reported for these primary mills.

Table II. Energy Balances

	Primary No. 1 Run 1	Primary No. 1 Run 2	Primary No. 2 Run 1
Energy inputs, 10^6 g cal per hr	237.5	259.5	219.5
Heat outputs, 10^6 g cal per hr	190.8	233.0	175.9
Surface energy, 10^6 g cal per hr	46.7	26.5	43.6
Efficiency, pct	19.7	10.2	19.9

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Economic Aspects of Ground Water in Florida

by V. T. Stringfield and H. H. Cooper, Jr.

ONE of the earliest investigations of ground water in Florida was made in 1513 when Ponce de Leon arrived at St. Augustine in search of the Fountain of Youth. The history of the development of the water resources of the State shows that the large artesian reservoir that underlies Florida was discovered in the latter part of the last century. Part of that history is given by L. C. Johnson[1] who states that the first successful artesian well in Florida was drilled at St. Augustine between 1880 and 1882. After the City of Jacksonville failed to obtain a flow of artesian water at a depth of nearly 400 ft and abandoned the drilling, R. N. Ellis, City Engineer, and L. C. Johnson, using Johnson's knowledge of the geologic structure of the artesian reservoir, estimated correctly that artesian water could be obtained at a depth of about 500 ft. Thus began the development of the large artesian system in the northeastern part of the State. In 1908, the Florida Geological Survey issued its first report on the ground water of central Florida.

More recent reports give the results of investigations that have been in progress in cooperation between the Florida Geological Survey and the U. S. Geological Survey since 1930. As a result, the groundwater geology and hydrology of Florida are now so well known that ground-water problems such as confronted early investigators no longer exist. However, new problems arise and new discoveries are made as the demand for more ground water increases with the development of the State.

Water-Bearing Formations

Descriptions of the geologic formations and a map showing their distribution at the surface are given in a recent report by Cooke.[2]

The geologic formations that yield the groundwater supplies in Florida represent only a small part (about 1000 ft) of the total thickness of the sedimentary rocks (more than 15,000 ft) that underlie Florida. The water-bearing rocks that yield fresh water include more than two dozen formations that range in age from Eocene to recent.

The Eocene formations, which consist chiefly of limestone, are the oldest and the deepest of the formations in Florida that yield fresh water to wells. In 1944, on the basis of a study of the foraminifera, the Applins[3] divided the limestone of Eocene age into six formations, which are as follows, from top to bottom:

Age or group	*Formation*
Jackson	Ocala limestone
Claiborne	Avon Park limestone
	Tallahassee limestone
	Lake City limestone
Wilcox	Salt Mountain limestone
	Oldsmar limestone

The Ocala limestone and the underlying formations of Claiborne age, along with some of the overlying limestone of Oligocene and Miocene age, constitute the principal source of water in Florida and southeastern Georgia and generally may be regarded as forming one artesian aquifer or water-bearing unit. This aquifer is referred to in this paper as the Floridan aquifer, a name proposed by Parker.[4]

In part of Seminole County alone more than 1000 flowing wells yield water from the Floridan aquifer. A yield of 6500 gpm, or about 9.5 million gal per day, by natural flow from a well penetrating the aquifer at Jacksonville, Florida, was observed in 1942. A yield of about 7000 gpm by natural flow was reported for a well 1390 ft deep at St. Augustine in 1887. The largest yield reported from a pumped well penetrating the aquifer is 7500 gpm, or about 10.5 million gal per day. The aquifer is also the source of some of the large springs, such as Silver Springs, whose discharge, according to measurements made by the U. S. Geological Survey, has ranged from 526 to 1350 sec-ft, or from 340 to 872 million gal per day.

The top of the Ocala limestone, as represented by contours in Fig. 1, indicates in a general way the geologic structure of the formations that comprise the Floridan aquifer. The Ocala is at or near the surface in the areas represented by shading in the northwestern part of the peninsula and also in an area in western Florida adjacent to Alabama and

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Georgia. In areas where it is structurally high, as in the central part of the State, it is cavernous. Sinkholes extending from the surface of the ground into the limestone are numerous where the limestone is at or near the surface.

Of the formations of Oligocene and Miocene age, the Tampa limestone of Miocene age is one of the most important as a source of artesian water. The Tampa overlies the Ocala limestone in the peninsula except locally where the Suwannee limestone[8-9] of Oligocene age (formerly known as the base of the Tampa) is present between the Tampa and Ocala limestones. The Tampa is at or near the surface in the west-central and northwestern parts of the peninsula, and in some of the area west of the Suwannee River. Well records indicate that it is not present in the eastern and northeastern parts of the State. The Tampa is the source of some of the large springs, such as Wakulla Springs, near Tallahassee.

The Hawthorn formation of Miocene age, or its equivalent, is present throughout the State, except where it has been eroded away and the older rocks are exposed. It overlies the Floridan aquifer and is in turn overlain by younger materials.

The Hawthorn consists of about 400 ft of interbedded marl, limestone, and clay, most of which is more or less phosphatic. In western Florida, west of the Apalachicola River, the possible equivalent of the Hawthorn is mapped and described[9] as the Chipola and Shoal River formations.

The Hawthorn formation contains permeable water-bearing beds in which water is confined by less permeable beds that lie above and below. The Hawthorn as a whole prevents the upward escape of much of the artesian water in the underlying limestones of Miocene, Oligocene, and Eocene age.

The surficial sands and the rocks that overlie the Hawthorn formation supply water to many shallow wells for domestic supply and also to some of the wells for public supplies—as those for Miami, Pensacola, and other cities in coastal areas where the deeper water is highly mineralized. Some of the shallow formations yield large supplies of nonartesian water. For example, the Tamiami formation of Pliocene age is one of the most productive formations ever investigated by the Geological Survey. This formation is the source of the municipal water supply of Miami, Miami Beach, and Coral Gables.

Source and Movement of the Water

The movement of the water in the artesian limestones in Florida is much more widespread than the movement of the water in the overlying formations. Water that enters the artesian limestones at some places travels more than 50 miles before it reaches an exit through a well or a spring. This fact is generally recognized and perhaps is responsible in part for the false notion that the artesian water of Florida comes from very remote places such as the Appalachian Mountains, the Great Lakes,[10] or the Rocky Mountains. All who are familiar with the groundwater geology of Florida recognize that the chief source of ground water is the rain that falls within the State and the water that moves from the southern parts of the adjacent States of Georgia and Alabama. However, much remains for the investigators of ground water in Florida to learn concerning the source and movement of the artesian water.

A report[11] of the Florida Geological Survey prepared in 1929 includes a map that represents the pressure head of the artesian water in the Ocala limestone in a large part of Florida. In 1933, the U. S. Corps of Engineers prepared a map showing contours representing the pressure head of the artesian water in north-central and northern Florida.

Confronted with the need for a better understanding of the occurrence, source, and movement of the artesian water, the U. S. Geological Survey, in cooperation with the Florida Geological Survey, in 1933 and 1934, prepared a map[12-14] of the Florida peninsula showing contours of the piezometric surface—an imaginary surface representing the height to which water will rise with reference to sea level in tightly cased wells that penetrate the Floridan aquifer. In the following year the two Surveys prepared a map of the piezometric surface[15] in the remainder of the State. These two maps proved to be so valuable in revealing information on the artesian water that they encouraged, in 1938, the mapping[16] of the piezometric surface in southeastern Georgia by the U. S. Geological Survey, in cooperation with the Georgia Department of Mines, Mining, and Geology. The piezometric contours in Florida and Georgia are given as Fig. 2. This map apparently covers the largest area for which a piezometric map has yet been prepared and is remarkable in that it shows the areas of recharge and discharge and the direction of movement of the artesian water over hundreds of miles. It also reveals important areas of recharge that were unknown before its preparation. The piezometric surface in the Florida peninsula, as shown in Fig. 3, has been described in a report by Stringfield,[17] and that in Georgia has been described by Warren.[18]

One of the most conspicuous features of the piezometric surface is in the central part of the Florida peninsula, in Polk and adjacent counties, where the surface has the shape of an elongated dome, part of which is 90 to 120 ft above sea level. This dome indicates local recharge of the water-bearing formation. Thus, recharge occurs south of the large area in which the Ocala and older limestones are exposed at the surface (see shaded area in Fig. 1). In the Polk County area the Ocala and Tampa limestones are overlain by relatively impervious beds of the Hawthorn formation, and therefore it might appear that little or no recharge would occur there. However, within the area are many lakes occupying old sinkholes now partly filled with permeable sands that permit downward percolation of water into the underlying limestone. As indicated by the absence of surface streams, the rainfall drains into the numerous lakes and depressions, providing a source of water for recharge of the formations. Water from the lake region of central Florida, therefore, supplies most of the artesian water in central and southern Florida.

Another area in which the piezometric surface is high includes the northwestern part of Putnam County and adjacent parts of Clay, Bradford, and Alachua Counties. In this area the piezometric surface ranges from about 50 ft to as much as 90 ft above sea level. Northward, in Bradford and Clay Counties, it forms a ridge 70 to 80 ft above sea level and extends at that altitude into Georgia. Recharge occurs in this area through sinkholes, or directly into the formations where they are exposed at the surface in the southern and southwestern parts of the area. In the northern part of the area, although the piezometric surface is as much as 70 ft above sea level, little, if any, recharge takes place locally, but

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GULF OF MEXICO
SEA LEVEL
EXPLANATION
Contour lines represent approximately the top of the Ocala limestone with reference to sea level. Contour interval 100 feet.
Area in which Ocala limestone is at or near the surface.

Fig. 1—The top of the Ocala limestone in Florida.

water is supplied through a recharge area in Georgia. Other areas in which the piezometric surface is relatively high, as where it forms a ridge extending from southeast Putnam County into Volusia County and where it forms a dome north of Tampa in Pasco County, indicate recharge areas.

Recharge occurs also in Marion County, where the piezometric surface forms a broad saddle between the Polk County and Putnam County areas. However, large quantities of ground water discharge in this area through large springs, such as Silver Springs and Rainbow Springs. Large areas of discharge occur where the piezometric surface is low along parts of the east and west coasts because in these areas the Ocala limestone is at or near the surface. There is also a large discharge area in the valley of the St. Johns River. Along the valleys of some of the rivers, such as the Withlacoochee and the Suwannee, where the water-bearing formations are exposed, the ground-water levels rise and fall with the stage of the river.

In Florida west of the Suwannee River, as might be expected, the general direction of the movement of the ground water is toward the Gulf Coast. One prominent feature of the piezometric surface in western Florida is the large embayment that follows the outline of the Gulf Coast in Wakulla, Taylor, Leon, and Jefferson Counties. In much of this area the Tampa limestone is at or near the surface and receives recharge directly from the rainfall. However, the piezometric surface is low because the rock is very permeable and cavernous and permits the artesian water to move relatively freely to the Gulf. East of the embayment, in Madison, Taylor, Lafayette, and Dixie Counties, the piezometric surface has the shape of a ridge extending, in general, in a southward direction, indicating that recharge occurs locally. The well data and the shape of the piezometric surface indicate that in this area the rocks are generally less permeable than in the area to the west.

In western Florida the piezometric surface is highest in Holmes and Jackson Counties, where the water-bearing formations are at or near the surface of the ground. In Escambia and Santa Rosa Counties the Tampa and Ocala limestones, or their equivalents, are far below the surface and are penetrated by only a few wells; therefore, the data are not sufficient for mapping the piezometric surface of these formations. However, the piezometric surface of the artesian water in the younger formations in Escambia County has been mapped.[10]

Wherever the piezometric surface is higher than the land surface, wells that penetrate the artesian limestones will flow. The areas of artesian flow in Florida are shown in Fig. 4. They include three principal areas: the Atlantic Coast, southern Florida, and the Gulf Coast. The map represents the areas of flow only approximately. Within the areas of flow are some relatively high regions in which wells will not flow. On the other hand, flows can be obtained in some low-lying areas that are not indicated as areas of artesian flow.

The height to which the artesian water will rise above the land surface in wells ranges from a fraction of a foot to as much as 65 ft. In the nonflowing wells, in higher areas, the water may stand as much as 100 ft below the ground surface.

Chemical Quality and Temperature

A report by Collins and Howard[9] and a report by Collins, Lamar, and Lohr[10] contain results of chem-

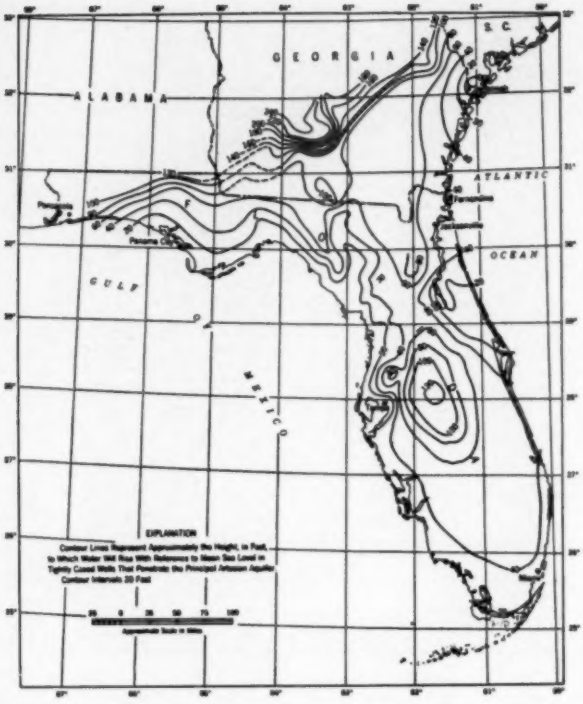

Fig. 2—The piezometric contours in Florida and Georgia.

ical analyses of samples of water collected throughout the State. Other reports[21-23] contain chemical analyses of water in different areas.

In general, most of the water in the Floridan aquifer is typical calcium bicarbonate water such as one would expect to find in limestone. In some parts of the State, as in southern Florida where the limestone contains gypsum, the water is relatively high in sulphate. The hardness of the water from limestone ranges from about 90 ppm in the recharge areas to more than 1000 ppm in water that has moved many miles through the limestone. The artesian water generally contains hydrogen sulphide as it comes from the wells, and hence it is aerated by most of the cities and towns that use it as a source of supply.

Ground water that occurs in sand and gravel is generally much softer than the water in the limestone formations. For example, water from a sand about 200 ft deep at Pensacola has only 41 ppm of dissolved solids and only 12 ppm of hardness. The water in the Floridan aquifer is relatively free from iron, but some of the shallow ground water has as much as several parts per million.

In recent years, as a result of a general recognition of the relation of the fluoride in drinking water to the development of teeth, determinations of the fluoride content of ground water have been made throughout the country. It is now understood that a fluoride content of about 1 ppm is the optimum for dental health; where the content is much less, the occurrence of dental caries (tooth decay) is relatively high, and where the content is greater than 1.5 ppm, the disfigurement known as mottled enamel is prevalent. Only one formation in Florida, the Hawthorn formation, yields water having a fluoride content of more than 1 ppm.[24] The maximum content in this formation, however, is less than 3.5 ppm.[25] The water that has a high fluoride content appears to come from beds that contain phosphatic material, which may be a source of the fluoride. The water from the Hawthorn formation is relatively hard. However, elsewhere in the Gulf and Atlantic Coastal Plains the water that has a relatively high fluoride content is soft and is generally associated with glauconite, bentonite, or volcanic ash. The occurrence of fluoride water in the coastal plain of Alabama is described in a paper by LaMoreaux.[26]

The chloride content of water, which may be used as an indication of the salinity, is especially significant in the coastal areas of Florida, where freshwater supplies may become contaminated by encroachment of salt water, and in a few places in the interior, as along the St. Johns River Valley and in the Everglades at the south end of Lake Okeechobee. Except in the areas where salt-water encroachment has occurred in recent time, or where the formation has not been completely flushed of the salt water that was present when the sediments were deposited or that entered the sediments when the sea stood at a higher level in the geologic past, the chloride content of the water is generally less than 20 ppm, and in many areas it is less than 10 ppm.

Fig. 5 shows the areas in which the artesian water has a chloride content of 100 ppm or more. The available information indicates that the relatively high chloride content, especially in the interior, as in southern Florida and in the St. Johns River Val-

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ATLANTIC OCEAN
GULF OF MEXICO
EXPLANATION
Contour lines represent approximately the height, in feet, to which water will rise with reference to mean sea level in tightly cased wells that penetrate the principal artesian aquifer, 1949

Fig. 3—The piezometric surface in the Florida peninsula.

ley, is caused either by traces of salt or salty water that was present at the time the formation was deposited, or by sea water that entered the formation during the Pleistocene epoch when the sea stood as much as 270 ft above its present level.

The temperature of the shallow ground water, as indicated by Collins,[27] is, in general, about the same as the mean annual temperature of the air. Near the ground surface the temperature of the water changes with the air temperature. The temperature of the water increases with depth, as the earth's temperature increases. In general, the temperature increases 1°F for each 50 to 100 ft of depth.

Collins indicates, on a map showing the approximate temperatures of water from nonthermal wells at depths of 30 to 60 ft, that the temperature ranges in Florida from about 70°F in the northern part of the State to more than 77°F in the southern part. Measurements of the temperature of the artesian water at the mouths of the wells in different parts of the State show a range from about 70°F to about 85°F. However, in one well in the southern part of the State, although only 620 ft deep, the water had a temperature of 88°F, which indicates a steeper thermal gradient (an increase of about 1°F for each 33 ft of depth) than that indicated at other wells.

Consumption

The large use of ground water throughout Florida emphasizes the fact that ground water is one of the most valuable minerals of the State. According to data compiled by the Florida State Board of Health,[28] there are about 357 public water supplies in Florida that serve 100 or more people, and of these, about 325 obtain their water entirely from wells. The public supplies serve a total population of 1,980,000, of which 79 pct is served by supplies from wells, and an additional 6 pct is served by supplies obtained partly from surface sources and partly from wells, or from springs and ponds that yield ground water. Practically all the nonpublic domestic supplies in Florida are from wells.

All the larger cities except Tampa, West Palm Beach, and Orlando obtain their water supplies entirely from wells, and Orlando obtains its water partly from wells. Among the larger cities using ground water exclusively are Jacksonville, St. Augustine, Miami, St. Petersburg, Lakeland, Daytona Beach, Gainesville, Tallahassee, and Pensacola. In the early development of the water supply of Tampa, wells were used, but they were near Tampa Bay and were ruined by salt-water encroachment—and so were the first wells of the municipal supply of St. Petersburg. However, by developing a well field at a safe distance from the coast, St. Petersburg has obtained its present excellent ground-water supply. The geologic and hydrologic conditions indicate that an adequate supply of ground water for Tampa could be obtained at a safe distance from Tampa Bay.

The water supply of Jacksonville is unique in that it is the largest municipal supply in the nation that is derived from the natural flow of artesian wells.

In comparison with other States, Florida ranks high in the number of flowing wells used for irrigation and in the value of crops irrigated by flowing wells. According to the U. S. Bureau of the Census,[29] 4631 flowing wells and 1686 pumped wells were being used for irrigation in 1940.

Florida ranks high also in the quantity of ground water used by industries. Among these, the phosphate industry probably uses the largest quantity of ground water. It is estimated that the phosphate

companies now operating in the State use an average of about 75 million gal a day. The paper and pulp industry is another consumer of large quantities of ground water. A total of about 65 million gal per day is pumped by the seven paper and pulp mills in Florida, one of which pumps about 30 million gal per day. Other industries that consume large quantities include citrus canning, citrus concentrates manufacturing, ice and cold-storage plants, air conditioning, resinous-products manufacturing, and mining of heavy minerals and limestone.

The total annual consumption, in gallons, of ground water in Florida is estimated to be as follows:

Public supplies serving 100 or more people	57,000,000,000[29]
Industrial supplies	70,000,000,000
Agricultural supplies	35,000,000,000[29]
Domestic supplies	15,000,000,000
Total	177,000,000,000

The total consumption is equivalent to an average of 485,000,000 gal a day. Considering that the value of the water used to be $0.05 per 1000 gal, the annual yield of the ground-water resources of Florida is now valued at about $9,000,000.

The total consumption of ground water is, of course, a heavy draft on the ground-water resources, but it should not be a cause for concern in regard to the State as a whole when it is realized that the ground-water reservoirs are naturally discharging many hundreds of millions of gallons of water a day, much of which can be salvaged and used whenever it is needed. Examples of the discharge are Florida's limestone springs, which rank with the largest in the world. These springs demonstrate the large capacity of the ground-water reservoirs. Among the largest of the springs is the Silver Springs group, which has a discharge that has ranged from 419 million to 756 million gal per day. The average flow of Silver Springs alone, about 500 million gal per day, is equal to the present total consumption of ground water in the State.

Difficulties Involved

However optimistic may be the outlook on the economic aspects of the ground-water resources of Florida, it should be remembered that many of the details of the ground-water geology and hydrology must be determined before an accurate estimate of the total ground-water capacity of the State can be made. The need for this information will increase as the consumption of water and the development of the State increase. Locally, the rate of withdrawal of water may exceed the rate of recharge, and so long as it does, water levels in wells will decline until they ultimately drop below the economic pumping lift or, in areas subject to salt-water encroachment, until the supply becomes contaminated with salt water. In addition to these problems of 1—decline of head and the accompanying decline in yield of wells and 2—salt-water encroachment, there are other complex problems, such as 3—the relation of deeper formations to the overlying aquifers, 4—the amount of leakage from one aquifer to another, and 5—artificial recharge and drainage of aquifers.

Decline of head: Large declines of water levels have occurred in only a few areas, including Fernandina, Jacksonville, and Panama City, where large quantities of water are consumed. In most, if not all, of these areas the rate of withdrawal apparently has not yet exceeded the rate of recharge. However, in each such area sufficient information on the ground-water geology and hydrology should be obtained to show what declines of water levels can be expected with any given rate of withdrawal and to show whether the area is in danger of salt-water encroachment.

A decline in the yield of wells generally accompanies a decline of water levels or artesian head. At Jacksonville and Fernandina, however, the yields of some of the large wells have declined considerably while the artesian head in the surrounding areas has remained relatively stable. This condition indicates that the water-bearing formations around the affected wells have become less permeable. The decrease in permeability is probably caused by precipitation of calcium carbonate in the pores of the limestone as a result of the reduction of hydrostatic pressure around the discharging wells. As yet, however, the phenomenon has not been investigated adequately and hence is not thoroughly understood.

Salt-water encroachment: Salt-water encroachment may occur where the aquifer is exposed to salt water and the water level declines to the extent that salt water may move into the aquifer. The general relations between salt and fresh water in coastal areas have been summarized by Brown.[24] The general conditions in Florida have been described in several reports.[25-28]

The principle of equilibrium between salt water and fresh water, as applied to the hydrology of sea coasts, is commonly referred to as the Ghyben-Herzberg principle,[25] and may be expressed by the formula, $h = t/g\text{-}1$, in which h is the depth of fresh water below sea level; t is height of fresh-water or hydrostatic head above sea level; and g is the specific gravity of the salt water. The specific gravity of sea water varies somewhat from one locality to another and may also vary with depth. If the specific gravity of sea water is 1.025, the fresh ground water will extend 40 ft below sea level for every foot that the ground water stands above sea level. This principle holds only where the salt water is in contact with the aquifer and can move into it when the fresh-water head is reduced.

Salt-water encroachment occurred in the old well fields of Tampa, St. Petersburg, and Miami. At Miami the encroachment was caused chiefly by the lowering of the water table with drainage canals. Salt-water encroachment can be avoided, of course, if the danger is recognized in time and the fresh-water head is maintained at sufficient level to prevent the salt water from entering the fresh-water aquifers.

The Ghyben-Herzberg principle does not apply to some problems of salt-water contamination. For example, in some places the water-bearing formations in Florida contain salt water that is the remnant of sea water present at the time the formation was deposited or of sea water that entered the formation when the sea stood at a higher level than it does at present. Fresh water, moving through an aquifer under those conditions, will become contaminated regardless of what the fresh-water head may be. Such conditions exist in the artesian aquifer in part of the St. Johns River Valley and in the interior south of Lake Okeechobee. Fig. 5 shows the areas in which the chloride content of the water is 100 ppm or more.

Relation between formations: The relation of the deeper formations to the overlying aquifers will be better understood after more wells have been drilled. Only a few of the water wells in Florida are more than about 1000 ft deep. In some parts of the State

Fig. 4—The areas of artesian flow in Florida.

additional ground-water supplies have been obtained from depths of more than 1000 feet. However, drilling to great depths should be done with care, because in much of the State the deeper formations contain salt water, some of which is under higher head than the fresh water. Careless drilling into salty water might, therefore, contaminate the fresh water supply.

Leakage from one aquifer to another occurs at some places where the water in one water-bearing bed is under higher pressure than that in the overlying or underlying beds. Under these conditions water may leak directly from one bed to the other or may move through uncased wells or through wells having defective casings. Only a few of the artesian wells in the peninsula are completely cased, and in many of the wells the open holes extend through several water-bearing beds. Thus, part of the water entering the wells from the beds that have relatively high pressure may escape into beds having lower pressure. Observed differences in head between water in the Ocala limestone and that in overlying beds of the Hawthorn formation range from a fraction of a foot to as much as 40 ft. Such leakage is known to occur in parts of the State, and it will occur over more of the State if new wells are not properly cased. Although no underground leakage was revealed in the exploration of wells with a deep-well current meter in Sarasota County,[8] it is entirely possible that some leakage had taken place but that the pressure of the water in the two horizons had reached equilibrium by the time the tests were made.

Artificial recharge and drainage: Wells are used at some places to drain surplus surface water into water-bearing formations, and at other places, where mining or construction operations require it, to unwater or drain shallow formations.

Surplus surface water is drained into wells in some parts of the lake region and in other areas where surface drainage is poorly developed and inadequate. At these places the water levels in wells stand several feet below the surface and surface water is drained into wells constructed for that purpose. The largest number of drainage wells are in Orange County, where the wells penetrate the Eocene limestone; and in Dade County, where the wells penetrate Pliocene limestone. In addition to the sanitary problem relating to these wells, there is also the problem of the capacities of the wells and of the aquifer to receive water, as discussed in several reports.[6,7,8]

If drainage wells operate under gravity flow, as they ordinarily do, the static water level in the wells must, of course, be below the level of the water being drained. Other factors being equal, the capacity of a well to receive water is more or less in direct proportion to the distance betwen the two water levels. Some wells drilled for drainage have overflowed under artesian pressure during wet seasons, thus aggravating the floods they were calculated to prevent. Therefore it is evident in this problem, as in the others, that adequate information on the geology and hydrology should be available to show the character of the water-bearing material, the occurrence of the water, and height to which the water will rise in the well, not only at the time the well is drilled but throughout the year, because seasonal water-level fluctuations of more than 10 ft may occur.

GEORGIA
ALABAMA
ATLANTIC OCEAN
GULF OF MEXICO
EXPLANATION
Area in which water having a chloride content of more than 100 parts per million occurs at moderate depths

Fig. 5—Areas in which chloride content of the water is 100 ppm or more.

In some mines high ground-water levels are a serious problem, and a study of the ground-water conditions is needed to determine the most economical means of controlling the water. Some of the problems in the mines in the Southeastern States are discussed by DeBuchananne.[4]

Other drainage problems require special ground-water studies in order to determine the correct solution. A unique problem of this kind arose during World War II in connection with a project at Hookers Point, near Tampa. The project called for the pouring of concrete hulls for ships in basins excavated below sea level, on a point of land adjacent to a body of sea water. The basins in which the hulls were to be poured were dug in land to be drained by pumping through sand points, and a reliable estimate of the required rate of pumping was needed in order to determine whether the project was feasible. On the basis of pumping tests to determine the permeability of the formations, the junior author gave an estimate which later was found to agree closely with the actual pumping rate.

In some areas surface drainage through wells or pits or by water spreading is beneficial in recharging aquifers in which the rate of withdrawal may exceed the rate of natural recharge. Artificial recharge of ground-water reservoirs—largely by water spreading—has been practiced at many places in the Western States[5] for many years. In the East, artificial recharge has been practiced at Runyon, N. J.,[6] for more than 40 years.

On Long Island, New York,[6] in 1944, more than 200 recharge wells and several recharge basins were in use for recharging the underlying aquifers at a summertime rate of about 60 million gal per day.

In central Florida,[7] the drainage of surface water into wells recharges the aquifers, although the purpose of the wells is to dispose of the surface water. The aquifer in Orlando and vicinity has the capacity to receive large quantities of water through wells, because the aquifer is very permeable and contains many solution channels. As artesian aquifers have very small capacities for storing additional water, the effects of artificial recharge in them disappear rapidly during periods in which the rate of recharge is light. Under these conditions a continuous supply of water for recharge during drought must be available if the piezometric surface is to be maintained at a high level.

Conclusions

The large consumption of water for industrial, municipal, domestic, and irrigation use emphasizes the fact that ground water is one of the most valuable of the industrial minerals of the State. It is estimated that 177 billion gal of ground water is used annually.

Along with an optimistic outlook on the economic aspects of the ground-water supply in Florida, it should be remembered that many of the details of the ground-water geology and hydrology are yet to be determined in order to estimate accurately the total ground-water capacity of the State. Some of these details involve complex problems, such as that of salt-water encroachment in some of the coastal areas.

It is evident that, although there is a general abundance of ground water in Florida, there is nevertheless a need for adequate investigations to provide information required for wise and careful planning of its development and conservation. The solution of the problem requires the combined efforts of engineers, geologists, chemists, and other investigators,

and the cooperation of the well drillers and owners of wells.

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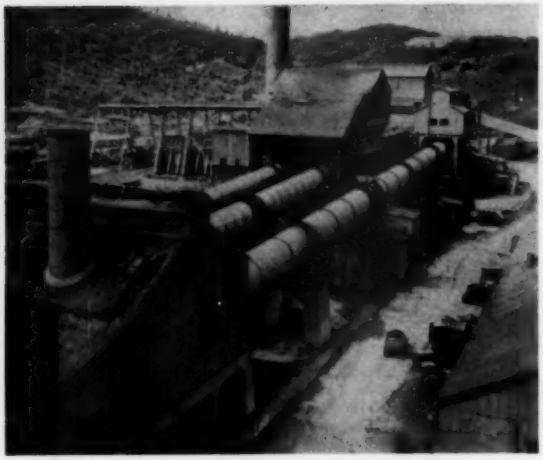

Fig. 1—Calaveras Cement Co.

The Calaveras Cement Co. Dust Suit

by Wm. Wallace Mein, Jr.

IN March 1949 the Calaveras Cement Co. was sued by five landowners whose properties are located in the vicinity of the plant. These landowners—all of them cattle ranchers—sued for dust damages of $120,338 and for an injunction preventing the company from casting dust upon their properties in injurious quantities. The issue was split, the jury deciding the amount of damages and the court handling the injunction features. The action came to trial before a jury in April of that year and resulted in damages being awarded in the amount of $7,508. A month later the court issued its injunction requiring recovery of stack dust to an 87 pct minimum.

The Calaveras plant, shown in Fig. 1, is located three miles from San Andreas in the heart of the Mother Lode country, about 45 miles east of Stockton, Calif. Since it is in a small town, the company's responsibilities to its employees and to the community are different from those of plants located in large centers of population. Construction of the plant was begun in 1925, and production was started the following year. Standard gray Portland cement as well as several specialty cements are produced.

Production facilities have been continually enlarged so that the present capacity is more than double what it was 25 years ago. The most important item in the company's expansion program was the purchase in 1945 of an 11 ft 3 in. x 360 ft Allis-Chalmers kiln which had been declared surplus by the Defense Plant Corp. The company is now able to produce about 2,500,000 bbl of cement a year, and employment at the plant is approximately 300.

The production of cement has always involved a dust problem, solution of which has been attempted in a number of different ways. By far the most efficient method of catching dust discharge is electric precipitation.

Soon after the company went into production in the 1920's, the landowners near the plant began complaining about dust discharge. The company settled the matter by paying them a total of $27,000 for dust damages incurred during the period from 1929 to 1938. In the latter year the two-unit Cottreli Electric Precipitator shown in Fig. 2 was installed and collected over 85 pct of the dust resulting from operation of the two 11 ft 3 in. x 10 ft x 240 in. kilns. From 1938 until 1946 the landowners registered no objection and were apparently satisfied with that dust recovery. In 1946, however, the substantially higher production resulting from operation of the new kiln immediately overtaxed the facilities of the existing two-unit precipitator.

In a short time claims for dust damages were again received from the landowners. The company informed them that because of postwar shortages it would take several years to install a new precipitator. The company stated that it intended to purchase an additional precipitator and offered in the meanwhile to pay the landowners a fair amount to cover their damages. This offer was rejected and the landowners filed suit in the Superior Court of Calaveras County asking for total damages of $120,-338 and for the injunction outlined above.

Case for the Ranchers

The attorneys for the plaintiffs produced three different types of witnesses: first, the landowners themselves and members of their families; second, other cattle raisers who were sympathetic to the plaintiffs; and third, several types of technical experts: veterinarians, soil chemists, and an aerial photographer. The testimony of these witnesses was designed to establish that the flue dust from the plant had not only damaged the land and the forage, but had also caused fluorine poisoning to their animals. By a combination of these causes, the plaintiffs attempted to prove substantial loss of profits.

WM. WALLACE MEIN, JR., Member AIME, is Vice President, Calaveras Cement Co., San Francisco.

Discussion on this paper, TP 3047H, may be sent to AIME by July 31, 1951. Manuscript, Nov. 18, 1949; revision, Feb. 2, 1951. Los Angeles Meeting, October 1949; New York Meeting, February 1950.

The plaintiffs introduced into evidence a mosaic map made from a large number of photographs taken by their aerial photographer at an altitude of 7500 ft above sea level, or approximately 6500 ft above the terrain in the area of the plant. The plaintiffs themselves, and virtually all the other witnesses too, told of heavy dust deposits which reduced the carrying capacity of the acreage and made their cattle sick, emaciated, and nonproductive.

Dust gaging stations were installed on the properties of all the plaintiffs and dust samples collected on vaseline-coated glass plates. The soil chemist hired by the plaintiffs also took soil samples, analysis of which, he testified, showed pH values above 8.0 in a majority of the cases, with a high in one sample of 9.7. A pH of 8.0 to 8.5 is excessively alkaline to the point of causing sterility in the ground. As a result, according to the plaintiffs' witnesses, there was a noticeable lack of the low growing grasses, which are the best feed.

The attorneys for the plaintiffs placed heavy reliance on the testimony of three veterinarians who stated that they had examined the animals of all five of the plaintiffs and had found definite symptoms of fluorine poisoning. Fluorine poisoning, they testified, was accumulative and progressive: Once it had advanced to the stage found in the plaintiffs' animals there was no hope of future recovery.

Claiming that the carrying capacity of the land had been greatly reduced by the dust, the plaintiffs said that they were forced to curtail drastically the size of their herds. Because of fluorine poisoning, their calve crops were greatly reduced. And finaliy, many of the remaining cattle were so stricken with fluorosis that they were not marketable as beef and could be sold only to the tallow factories. This situation was pictured in the framework of a cattle market in which the price of calves had doubled in value between 1945 and 1948. It was their contention that damages should include a figure representing a capitalization of their lost profits.

They maintained in addition that they were entitled to further damages for nuisance and inconvenience suffered in their residences. The ranchers' wives who lived on their properties stated that the dust doubled the amount of housework, covered their food, clothing and furnishings, and made living conditions intolerable.

Case for the Cement Company

The company's attorneys had anticipated and made preparations to answer most of the contentions in the plaintiffs' case. Testimony was prepared to contradict their claims for damages to the land, forage and cattle. The charge of fluorine poisoning, however, was a complete surprise. It was necessary to prepare in a few days, testimony which would refute this charge by the landowners. In defense of this charge Calaveras used as its consultant Professor Emeritus Robert E. Swain of Stanford and as its expert witness, a toxicologist, Dr. Charles Hine.

The company's other witnesses were similar to those produced by the plaintiffs—veterinarians, chemists, and soil analysts. The company also put cattle ranchers on the stand, and in addition, a local real estate broker, the plant superintendent, the assistant superintendent, and one of the plant engineers.

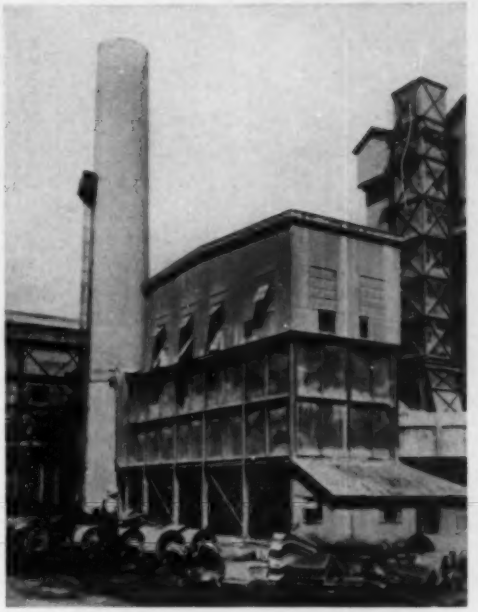

Fig. 2—Two-unit precipitator installed in 1938.

The company engineer had spent several months before the trial investigating the dust areas in the vicinity of the plant. An aerial photographer was employed to take pictures of this area at an altitude of 2500 ft above sea level, or 1500 ft above the land's surface. From these photographs and from observations made on foot by the engineer, a dust survey of the area was prepared on a blown-up U. S. Geological Survey map. The acreages of each of the ranchers were segregated into five composite dust zones—(1) very heavy, (2) heavy, (3) medium, (4) light, and (5) very light.

Calaveras introduced into evidence an exchange of correspondence between its attorneys and the plaintiffs' attorneys in which a request to erect test stations on the ranchers' properties was refused. The company then produced a legal order granted by the court giving its witnesses the right to visit and examine the properties.

Several months before the trial Calaveras had hired an agronomist to make a survey of the plaintiffs' lands and their cattle. Photographs and slides which he exhibited showed superior forage crops and fine specimens of cattle.

The agronomist took forage samples and soil samples from six different locations on the plaintiffs' lands. Analysis of the soil specimens indicated that the pH values on the ranchers' lands were just about neutral. The extreme low was 7.13 and the extreme high 7.85. He stated that operation of the cement plant had not damaged the soil or the surface of the

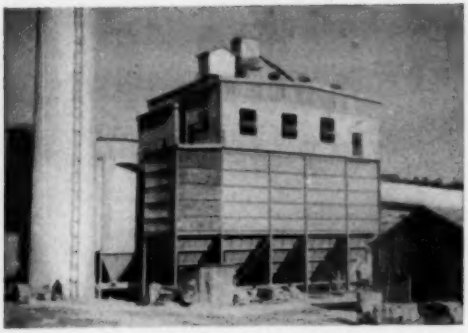

Fig. 3—Precipitator installed in 1949.

plaintiffs' lands either on the basis of plant growth or of chemical analysis. He admitted that the forage crops had become covered with dust which made them less palatable during the dry season, but he stated that this dust actually benefited growth of clover and other choice grasses.

The testimony of the company's next two witnesses, its Chief Chemist and the Chief Chemist for Twining Laboratories at Fresno, refuted the principal contention of the landowners. The Calaveras witnesses went to the three most important gaging stations used by the plaintiffs for collecting dust on the vaseline-coated glass plates. Here, on the ground around the same telephone poles put up by the plaintiffs for their own dust determinations, the company chemist gathered samples of both forage and soil and sent them to the Twining Laboratories for analysis. Then, for complete contrast, samples were taken at a fourth point 15 miles away from the dust zone. The Twining chemist found that the grass samples taken at this location actually contained 20.9 parts per million of fluorine, compared to 3.8, 9.5, and 13.3 parts per million in the samples taken at the landowners' gaging stations. Analysis of the soil samples revealed that the soil at the 15-mile point contained 59.5 parts per million of fluorine as against an average of 7.8 parts per million in the samples found underneath the three gaging stations.

Dr Hine stated that he had examined 16 of the plaintiffs' animals several days before and had found absolutely no sign of fluorosis. His calculations showed that an animal would have to consume 15 times its normal intake of 30 lb of food per day to obtain a toxic amount of fluoride, namely, 200 parts per million.

In order to establish a reasonable figure for loss of rental value, the company produced a local real estate broker and several ranchers in the community, all of whom testified that they were familiar with the land values of the five ranchers compared to values of other property in the area. These witnesses stated that the plaintiffs' lands and forage crops compared quite favorably to similar grazing property outside of the dust zone. They confirmed the agronomist's statement that the best food grew on the land with the heaviest dust deposits. Each of these witnesses calculated what he thought was a reasonable loss of rental value for the five rancher plaintiffs. Their estimates averaged $4,600 total loss of rental value during the 4-year period of dust damages.

In summing up the case, Calaveras's attorney was frank to admit that the plant had created a dust nuisance during the period in question. He stated, however, that the extent of this damage had been enormously exaggerated by the plaintiffs and should be limited to the much lower loss of rental value as calculated by the witnesses. He emphasized the spurious nature of the fluorine claim made by the plaintiffs. Finally, he stated that the plaintiffs' animals which the company's witnesses were allowed to examine were in poor condition because of old age, lice, and an adverse winter, rather than because of any fluorine poisoning from their forage.

Verdict and Aftermath

Two weeks after the opening of the trial the jury brought in its verdict awarding the ranchers a total of $7508 for damages, instead of the $120,338 for which they had sued.

The award of damages, however, was only half of the suit. The other portion of the suit was the request for an injunction which the judge announced at the outset would be decided by him later without benefit of the jury. A month after the jury verdict, the judge held a hearing on the injunction proceedings. The Calaveras plant superintendent pointed out the importance to the community of the continuing operation of the cement plant. He testified that the 1948 annual payroll to Calaveras County residents was close to a million dollars and that local trucking operators secured an additional half a million dollars worth of business from the company each year. Finally he showed that to enjoin the company from discharging any dust at all would shut down the plant, thus resulting in a far greater loss to the stockholders than the limited loss to the landowners in the partial dust discharge.

After hearing the testimony, the judge requested that each side prepare what it considered a proper order. The proposed draft which Calaveras presented stipulated recovery of not less than 87 pct of all flue dust that would be discharged from the kilns in the absence of any control. In determining the amount of dust discharge, the company recommended use of the method described in Bulletin WP50, entitled "Method for Determination of Velocity, Volume, Dust and Mist Content of Gases," published by the Western Precipitation Corp. The proposed injunction prepared by the plaintiffs' attorneys provided that the cement plant would be permanently enjoined from operating in such a manner as to cause injury to the soil, vegetation, cattle, or homes of the five plaintiffs.

Shortly, thereafter, the judge adopted an order and injunction along the lines of the draft submitted by the company. A few days prior to June 30, the grace period, the company's new precipitator was placed in operation. The Western Precipitation Corp. had assured that the new precipitator, Fig. 3, operating in conjunction with the existing one would have no difficulty in collecting 87 pct of the flue dust discharge. The total cost of installation was approximately $185,000. The annual operating cost for the precipitators is $26,000 before depreciation and $47,000 including depreciation.

Later that year, the plaintiffs' motion for a new trial was denied by the court. However, in the following month, the plaintiffs filed an appeal in the case. It was their contention that their own version of the injunction asking that the plant be prevented from discharging dust in injurious quantities should be the one adopted by the court. This appeal is still pending.

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aime NEWS

Industrial Minerals Division Plans Morgantown, W. Va. Meeting

Continuing its series of four regional meetings which began in Oregon in April, and which will continue in California and Mexico in October, the Industrial Minerals Div. of AIME will hold an Eastern Regional Meeting in Morgantown, West Va., from Sept. 13 to 15. The Central Appalachian, Ohio Valley, and Pittsburgh Sections have been invited to cosponsor the meeting, at which papers of both regional and national interest will be presented.

Both technical sessions and field trips will be held on the first day of the meeting, with papers of regional interest scheduled for that day. The field trips will take registrants to raw materials operations and manufacturing plants near Morgantown. Sept. 14 will be devoted to a symposium, nationwide in scope, on the important subject of "Industrial Minerals as Raw Materials in the Chemical Industry." A banquet will be held that evening. Field trips will be continued on Saturday, Sept. 15, and will end by noon of that day.

J. C. Ludlum and H. Wm. Ahrenholz, Jr., both of the University of West Virginia, will be in charge of the local program committee and general arrangements, respectively. P. H. Price of the West Virginia Geological Economic Survey is in charge of the local committee. In addition, J. S. Machin's Committee on Chemical Raw Materials is expected to play an important role in the Sept. 14 symposium. Mr. Machin heads the Industrial Minerals Div. of the Illinois State Geological Survey.

Those who wish to contribute papers to the meeting should contact Professor J. C. Ludlum, 313 Minerals Industries Bldg., University of West Virginia, Morgantown, W. Va.

B. C. Snell Joins Advertising Staff

Byron C. Snell joined the advertising staff of MINING ENGINEERING and the JOURNAL OF METALS on May 1. He will work with James A. Stangarone, who henceforth will sell space in both publications rather than in the JOURNAL OF METALS alone. Mr. Snell will make his headquarters in Pittsburgh and Mr. Stangarone in New York.

Mr. Snell graduated from Ohio State University in 1933. For the past nine years he has been regional business manager for the Penton Publishing Co., covering the territory tributary to Pittsburgh for *Steel* magazine.

The new arrangement follows the resignation of Wheeler Spackman as advertising manager of MINING ENGINEERING and its predecessor, MINING AND METALLURGY.

Messrs. Snell and Stangarone will cover the East and Middle West, McDonald-Thompson continuing to act as publisher's representatives in the Pacific Coast, States for MINING ENGINEERING and for the JOURNAL OF PETROLEUM TECHNOLOGY in the oil areas west of the Mississippi.

Anthracite Laboratory Open House

Research on mine mechanization, preparation, and utilization of anthracite coal is the objective of the new Anthracite Research Laboratory of the U. S. Bureau of Mines, Schuylkill Haven, Pa. The laboratory held an open house for the Pennsylvania Anthracite Section on Apr. 27, which was followed by a dinner meeting at the Schuylkill Haven Country Club. Over 275 members were present to hear John W. Buch, director of the laboratory, and his associates describe the projects which are being undertaken. John D. Cooner, Sr., in charge of the mining branch of the laboratory described new equipment being tested which included a shaker scraper, a coal planer, several types of coal shearing machines, a telescopic shield for roof support up to the breast, and load detectors and an automatic recorder used in preliminary work to design the shield for determining ground loads. A bone coal gas producer project is expected to get started within a month or so. Chairman Henry A. Dierks presided at the meeting and introduced the guests which included three well-known educators, Dean Steidle of Penn State, and Professors Callen and Gallagher of Lehigh, and C. H. Maize, state mine inspector.

AIME Authorizes Five Awards

AIME Board of Directors has authorized granting five awards at the annual meeting in 1952. The name of the award, the purpose for which granted, and the name of the chairman of the committee appointed to select the recipient are as follows:

Charles F. Rand Medal for distinguished achievement in mining administration, the term mining to be broadly interpreted to include metallurgy and petroleum. Eugene Holman, chairman of the Rand Metal Committee, is with Standard Oil Co. (N.J.), 30 Rockefeller Plaza, New York 20, N. Y.

Mathewson Medal for the Institute of Metals Div., paper which represents the most notable contribution to metallurgical science in the three-year period preceding the award. C. E. Nelson, chairman of the Mathewson Medal Committee, Dow Chemical Co., Midland, Mich.

Robert H. Richards Award to recognize achievement in any form which unmistakably furthers the art of mineral beneficiation in any of its branches. H. A. Pearse, chairman Richards Award Committee, Howe Sound Co., 730 Fifth Ave., New York, N. Y.

Robert W. Hunt Award for the best AIME paper on iron and steel. T. L. Joseph, chairman Hunt Award Committee, University of Minnesota, Minneapolis, Minn.

J. E. Johnson Jr. Award to a man under 40 who has exhibited exceptional ability in research, invention, or contributions to the technical literature related to the metallurgy or manufacture of pig iron. Paul R. Nichols, chairman Johnson Award Committee, Wisconsin Steel Works, South Chicago, Ill.

1951 AIME Budget Shows Surplus

At the April meeting of the Board of Directors the final budget for the current year, showing a surplus of $6430, was adopted. Total income is expected to be $502,700, compared with $493,689 in 1950; expenses, $496,270, compared with $511,411 in 1950. The budget is believed to be conservative, based on present costs.

PROPOSED BUDGET FOR 1951

	FINAL BUDGET 1951	1951 MINING	1951 METALS	1951 PETROLEUM
INCOME				
Dues:				
Current	$272,000	$142,038	$66,204	$63,758
Arrears	4,500	2,327	1,111	1,062
New	25,000	10,000	6,250	8,750
Initiation	17,000	6,800	4,250	5,950
Total	$318,500	$161,165	$77,815	$79,520
Publications:				
Advertising	$125,000	$63,000	$45,000	$27,000
Journal Sales	17,000	6,000	7,000	4,000
Transactions Sales	20,000	7,300	6,400	6,300
Other Sales	4,000	1,500	972	1,528
Total	$176,000	$77,800	$59,372	$38,828
Other income:				
Interest	$5,200	$2,600	$1,200	$1,400
Miscellaneous	3,000	1,566	730	704
Total	$8,200	$4,166	$1,930	$2,104
TOTAL INCOME	$502,700	$243,131	$139,117	$120,452
EXPENSES				
Membership and Sections:				
Sections, traveling, etc.	$15,000	$8,000	$3,800	$3,200
Divisions and Branches	56,000	24,823	13,377	17,800
Meetings	1,000	522	243	234
Library Assessment	6,500	3,394	1,582	1,523
Building Rental	13,000	6,770	3,180	3,052
Secretary Travel	2,500	1,306	608	586
Total	$94,000	$44,815	$22,790	$26,395
Publications:				
Journals	$252,500	$112,500	$92,000	$48,000
Transactions	26,000	9,250	10,110	6,640
Directory (Comm. list)	2,000	1,000	520	480
Other	10,000	—	—	*10,000
Total	$290,500	$122,750	$102,630	$65,120
General and Administrative:				
Salaries, other	$49,000	$25,521	$11,976	$11,502
Accounting and salaries	25,000	13,121	6,035	5,853
Membership and salaries	21,000	10,921	5,144	4,933
Pensions and annuities	7,000	3,788	1,604	1,607
Insurance	1,000	522	243	234
Furniture and fixtures	2,000	1,044	486	468
Miscellaneous	4,000	2,088	973	937
Social Security Tax	2,160	1,127	525	508
N.Y. State Disability	610	318	148	144
Total	$111,770	$58,450	$27,134	$26,186
TOTAL EXPENSES	$496,270	$226,015	$152,554	$117,701
UNEXPENDED INCOME	$6,430	$17,116	($13,437)	$2,751
Appropriation Income Rocky Mt. Fund (Mining Secretary) contingent	12,000			
Unexpended balance including appropriation	$18,430			

* Petroleum Statistics Volume.

Details of the over-all budget, as well as the breakdown by Branches, are shown in the accompanying table.

Last year the Metals Branch had a deficit of close to $42,000. This has been cut down in the 1951 budget to $13,437. Advertising income in the JOURNAL OF METALS is showing a healthy increase, justifying the money that was put into the journal to get it established. Its net advertising income in 1949 was $11,000; in 1950 $30,000; with $45,000 budgeted in 1951.

The Mining Branch expense for 1951 includes for the first time an appropriation for the Western Secretary and the expenses of his office, amounting to $12,000. If there should be a deficit for the year, the Rocky Mountain Club Fund has promised to meet it up to this $12,000 figure, adding a safety factor to the budget.

For the first four months of 1951, AIME income was $336,610, or $27,428 in excess of the same period in 1950. Expenses were $184,642 or $14,721 less than in the same period last year.

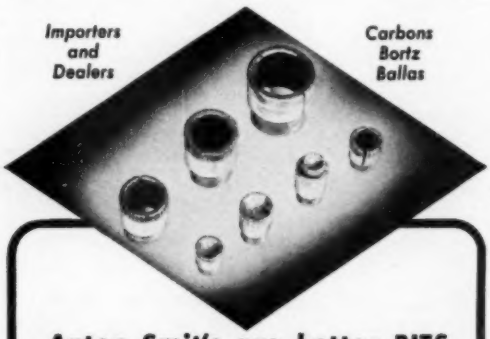
Coal Men to Meet in June

The Central Appalachian Section of the American Institute of Mining and Metallurgical Engineers will meet in Middlesboro, Ky. on June 15 and 16. C. E. Lawall, assistant vice-president of the Chesapeake & Ohio Railway Co., Huntington, W. Va., is in charge of the program and C. H. Hodgson, district manager of Mine Safety Appliance Co., Hazard, Ky., is in charge of arrangements.

Dr. H. L. Donovan, president of the University of Kentucky, will be a guest speaker at the banquet to be held at the Cumberland Hotel on Friday evening, June 15. Dean Earl Norris, of the College of Engineering at Virginia Polytechnic Institute, will address a luncheon meeting on the same day.

Several interesting technical papers will be presented by outstanding men in the mineral industries field. Among the many fine papers will be one on "Lower Cost Coal to Meet Competition" by M. Albert Evans of Pittsburgh; "Large Augers for Highwall Mining" by Professor D. M. Bondurant of West Virginia University; "Effect of Unmined Seams of Coal by Mining Coal Seams Above and Below" by C. T. Holland, dept. of mining engineering at VPI; and "Cleaning of Fine Sizes of Coal by Flotation" by E. C. Carris, assistant to the president, Roberts & Shaeffer Co.

John T. Parker, Inland Steel Co., Wheelwright, Ky., is chairman of the Section, and will preside at the June meeting.



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Northwest Industrial Minerals Conference Holds 2-Day Meeting

The fourth annual Northwest Industrial Minerals Conference, sponsored by the Oregon Section of AIME and the Industrial Minerals Div., attracted over 80 persons to the 2-day meeting. The all-day technical session held on Friday, Apr. 27, at the Congress Hotel was devoted to the presentation of papers dealing with the industrial minerals of the Pacific Northwest. The morning session, co-chairmanned by L. C. Richards and G. E. Waterman, opened with a symposium on the economy of Pacific Northwest industrial minerals.

A comprehensive paper on the industrial minerals used in paint manufacture in the Pacific Northwest was given by James G. Hohn of Van Waters & Rogers Co., industrial minerals wholesalers. A lively discussion period found many of those present asking for advice on house painting, in addition to technical questions on pigments.

At the noon luncheon, which was held in the Mirror Room of the Portland Hotel, Richard J. Anderson of Battelle Memorial Institute gave a short talk on new uses for industrial minerals, which he followed with an illustrated talk on activities at Battelle.

The afternoon session, with J. W. Melrose and Drury Pifer presiding as co-chairmen, included a talk by Dean George W. Gleeson of the School of Science at Oregon State College, on "a summary of the black sands of the Oregon coast." The sands have attracted the interest of miners for a good many decades. Gleeson declared that under present circumstances there is little possibility that the deposits can be worked economically but that they do constitute a potential source of chromic oxide in times of national emergency. There are also small percentages of zirconium, rutile, monazite, and several noble metals which could be recovered.

Woodrow L. Burgess, concrete engineer with the Corps of Engineers, U. S. Army, outlined the preparation given to aggregates used at Detroit dam. Recent advances in concrete engineering in connection with large monolithic dam structures have stressed the need for closer and closer tolerances on specifications for aggregates, cements, and temperature of the concrete when placed. The Detroit dam, located on the North Santiam River in the Oregon Cascades, has one of the most modern aggregate processing and preparation plants in the country and is equipped with a tempering section for controlling aggregate temperatures so that the delivered concrete will have a temperature not exceeding 50°F. The tempering section provides incidental washing of aggregate since there is no water used in the various units of the preparation plant prior to its introduction into the inundation cooling portion of the plant.

William E. Cox read a paper on the dimensional change studies of unit masonry, which had been prepared by J. J. Wegner of Washington Institute of Technology. The study of the causes of shrinkage in precast pumice blocks is one of considerable interest to the area since large deposits of excellent grade pumice occur in central Oregon. Mr. Wegner's paper indicated that the pumice blocks undergo a permanent net contraction during the first 45 days after the blocks leave the steam kiln, and that wire reinforcements used in the mortar joint exercise a considerable restraint on the horizontal dimension change of the block panels.

James A. Barr of Armour & Co. gave an illustrated talk on recent advances in minerals beneficiation. He brought out the point that numerous flotation reagents that performed satisfactorily had been discovered accidentally and that considerable research has been expended in learning just why or how they work. The use of radioactive atoms obtained from the Atomic Energy Commission was also described. The tagged atoms greatly simplify the tracing of the various mineral fractions during their passage through a flotation cell.

Following the technical session, the delegates were entertained at a cocktail party which preceded the evening banquet. The principal address of the evening was given by A. B. Cummins, director of research of Johns-Manville Co. Dr. Cummins reviewed the various phases of the asbestos industry, and a new color film showing the mining, milling, processing, and uses of asbestos was shown.

Despite several drenching showers during the day, 35 moisture-resistant delegates turned out for the Saturday plant tours. First stop of the motor caravan, which was organized by Ernest Messer, was at the Smithwick Concrete Products Co. haydite plant located at the eastern edge of Portland. This plant boasts the largest rotary kiln used by the industry, the kiln measuring 100 ft in length by 8 ft diam. After an inspection of the plant equipment, the group was given a short description of the plant and process by S. Carl Smithwick, president of the company. Coffee and sinkers were provided to raise the early morning spirits of the tourees. The Wagnermobile Co. plant, which manufactures the well-known Scoopmobile line of materials-handling equipment was given a thorough going over by members of the tour, after which they were shown several short colored films of company products in operation. N. A. Heckman, salesman for the company, conducted the group through the plant.

A noon luncheon was enjoyed at The Dahl House in Oswego. The Oswego cement plant of the Oregon Portland Cement Co. occupied the tour members for the balance of the afternoon. This plant produces some of the finest Portland cement being produced on the Coast and has recently added to its capacity with the addition of a new 9-ft diam oil-fired kiln.—*Ralph S. Mason.*

Mexico City Meeting Reminder

Those who plan to attend the 6-day inter-American convention on mineral resources, to be held Oct. 29 to Nov. 3 in Mexico City, are advised to make their hotel reservations early. Another opportunity to do this is afforded by the attached coupon.

The meeting, which affords an excellent opportunity to combine business with pleasure, will include papers by two South American groups, as well as the Texas Geological Society, and four AIME Divisions. Field trips and sightseeing will be accented.

As was reported last month, the dollar is worth more in Mexico, with prices one-third lower than at home. Excellent accommodations for the meeting are available for between $3.50 and $8 per day for single rooms; and $4.50 to $8.50 per day for double rooms.

Further details about the meeting will be presented in forthcoming issues of MINING ENGINEERING, including details about entry into Mexico, a full meeting program, and news about field trips.

Mr. William G. Kane
San Juan de Letran 9, Room 805
Mexico, 1, D.F.

Please make the following reservations for me for the October meeting:

Single Room ..... Double Room with twin ..... double ..... beds, at about $..... per day. There will be ..... men and ..... ladies in my party. Expected date of arrival .....; departure .....

.....

Name .....

Title and Company .....

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City, Zone, State ..... MES

Drift of Things . . . . . as followed by **Edward H. Robie**

EVERY year new words, phrases, or methods of expression rise to temporary fame. Such, for example, was the word *normalcy*, popularized by President Coolidge. A year or so ago we mentioned the new vogue for *presently* instead of *currently*, *presently* having usually meant *pretty soon* instead of right now.

A few years ago *Time*, we believe it was, began writing it $8 million instead of $8,000,000, and the practice of expressing large sums in this way has spread to most newspapers and magazines. We presume the reason for this style was to avoid a row of cyphers; there is no saving in the space used, at least not until we get into the billions. We still are not sure just how this should be read. Are we supposed to read it eight million dollars, or eight dollars million? If the former, then what do you do when the $8 comes at the end of a line, or column, or page? You see the $8 but your eye has to travel elsewhere to see the million. A well-known columnist puts it this way: 8 million $, which makes more sense, if one can get used to seeing a dollar sign all by its lonesome.

Perhaps the most noticeable comet in the present linguistic sky is the common use of the awkward expression "as of." This originally was legal jargon, and confined to financial reports and such where it sometimes had a useful significance. But now we read in the paper, "Unfilled orders *as of* Dec. 31 were $91,260,000." Why not *on*? In a newsletter: "The cost-of-living index made a new all-time high *as of* Feb. 15." Why not "The Feb. 15 cost-of-living index. . . .? And the radio: "*As of* right now, the forces of nature seem to be under control." Why the *as of*? Also, "The Jersey Central is shutting down services *as of* 1 o'clock tomorrow." Why not say *at*? In "All About Eve," "*As of* this moment, you are six years old." Again, why not *at*? And in the U. S. Steel report, "U. S .Steel's ingot capacity has been increased to give a total annual capacity, *as of* Jan. 1, 1951, of 33.9 million tons." Why not say *on*?

We suspect that those who use this bit of frippery unconsciously think they are utilizing one of the super niceties of expression. As a matter of fact, 99 times out of a hundred, they are using a clumsy phrase that could better either be omitted entirely or be replaced by one two-letter word.

Another adaptation of the last few years is use of the word *defense* instead of *military* or *war preparation*. Good psychology is back of this euphemism. No one can object to defense of the country, but everybody is fed up with war as a means of settling international difficulties.

AIME Student Problem

A variety of problems pertaining to the payment of AIME dues is constantly arising. Perhaps a few case histories will prove informative, so in this issue we will start with one that happens to have crossed our desk just recently.

A young man was elected a Student Associate in the fall of 1946 and paid his initial dues carrying him through 1947. He made no payment for 1948, 1949, or 1950, so was dropped at the end of 1949. He now wishes to be reinstated and to be assured that his membership will date continuously from 1947.

When AIME headquarters learned that he wished to be reinstated he was sent a bill for $1 for arrears in dues and $4.50 for current dues, including a journal subscription. The gentleman in question said it was not clear to him if payment of the $1 covered (1) payment in full for the back dues for 1948, '49, and '50; (2) reinstatement in good standing; or (3) whether or not his original election date would be retained.

In reply we told him: "It has been our practice to accept $1 as a reinstatement fee for Student Associates who have been dropped as owing two years' arrears in dues. This is equivalent to one half of the $2 formerly charged Student Associates as annual dues. Beginning in 1951, however, Student Associates who have not paid their dues by March 31 of any year are thereupon immediately dropped; thus no arrears will accumulate and the young man can later be reinstated without any charge other than dues for the year of reinstatement.

"To maintain his original election date a Student Associate or any other member must pay his dues continuously for the full amount, otherwise the date of his reinstatement becomes his election date on our records. To be recorded as a member of 1947, it would be necessary in the present case to pay $6, covering dues for 1948, '49, and '50, together with the $4.50 for 1951 which includes a journal subscription."

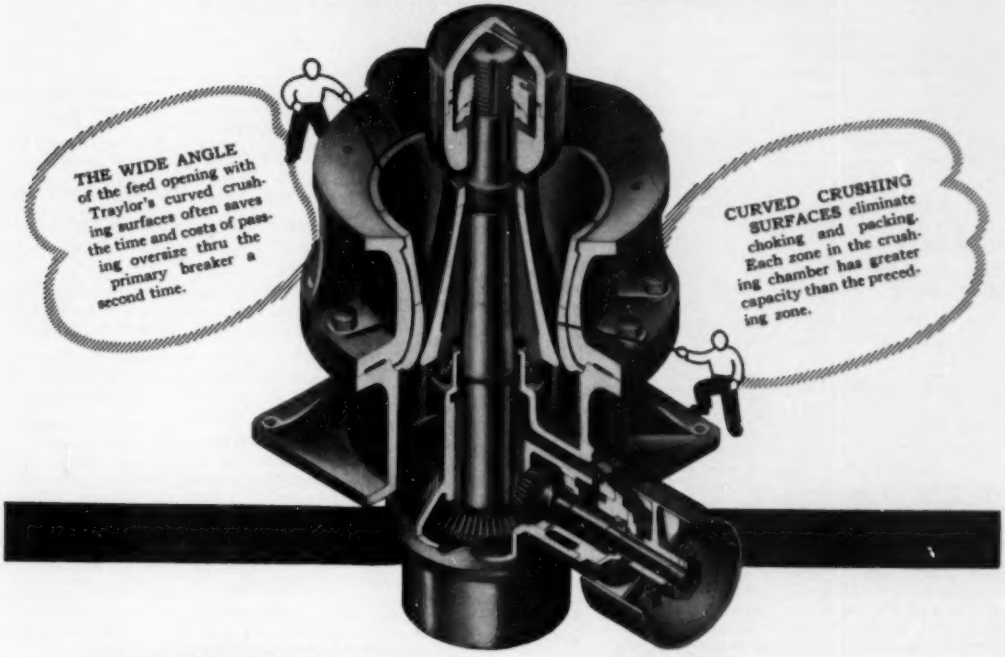
Bureau of Mines Films

An important activity of the Bureau of Mines that perhaps has not had the recognitior it deserves is its motion picture work. Not only does the Bureau promote the making of films covering the mining, metallurgical, petroleum, and allied industries, but it maintains a free loan library of more than 16,000 reels. Last year its motion pictures were shown more than 177,000 times before audiences of 12 million people, not including showings by television.

This is one Government activity, and one of the more worthwhile ones it may be added, which costs the taxpayers comparatively nothing. The companies whose operations are depicted in the films have been eager to cooperate and to pay all production costs, even though the Bureau does not allow any trade marks, trade names, or advertising material to be shown. The only company identification is the name of the sponsoring company at the beginning and end of each film. Apparently the companies feel that even this modest mention of their name is worth the cost of the film in making for better employee morale and good public relations. Then, too, they have a sense of professional responsibility and pride in showing an interested public the highlights of their practice. They choose their own producing company, but the Bureau scrutinizes the scenario to make sure that the picture will be suitable for public showing on a noncommercial basis. Many, if not most, of the more recent films are in color. Both silent and sound films are included in the library.

Any companies that feel their operations are likely to be of sufficient public interest to warrant film recording should apply to M. F. Leopold, Bureau of Mines, Washington 25, D. C. Mr. Leopold, who joined the Bureau when it was created in 1910 and recently received the Interior Dept.'s gold medal for distinguished service, is well-known throughout the mineral industry. Those groups who wish to borrow the films for showing should apply to the Bureau of Mines Graphic Services Section, 4800 Forbes St., Pittsburgh 13. A catalog is available, as well as special publicity releases on all the new films as issued.

a Traylor TY Reduction Crusher will nip larger rocks than other secondary fine crushers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Personals

John N. Butler of Monticello, Utah has resigned as resident engineer for the Galigher Co.

Thomas P. Billings, consulting engineer at Salt Lake City, has accepted a position with the AEC in Washington, D. C.

W. F. Camacho-Navarro, mining engineer for Ohio Basic Refractories, is now located at Santiago, Cuba where he is prospecting a new mineral property.

Paul R. Clevanger has joined the Welex Jet Services, Inc., Kilgore, Texas.

Thomas Ford Clemens is now associated with the Consolidated Coppermines Corp., Kimberly, Nev.

James E. Collord is manager of the Mullin Mines Co., Golden, Idaho.

J. M. Currie has joined the Van Roi Consolidated Mines Ltd., Silverton, B. C.

Francis T. Coleman, Florence, Ariz., is now civil engineer with the Kennecott Copper Corp., Hurley, N. Mex.

Lawrence E. Cole, manager, and **John Towers,** assistant superintendent, U. S. Metals Refining Co., Carteret, N. J. recently completed a visit to many of the company's western smelters.

J. A. Carpenter, 25 years with the Mackay School of Mines, is retiring at the end of the school year. He graduated from the University of Nevada cum laude in 1907 and taught metallurgy there from 1908 to 1910. In 1911 he received his masters from the University based on the thesis of his design of the West End mill. In 1949 he received the honorary degree of Dr. of Science from the University. He plans to open a private practice as mining engineer and consultant in Nevada.

J. A. CARPENTER

A. P. CORTELYOU

Arthur P. Cortelyou has been appointed general manager of the U. S. Vanadium Co., a division of Union Carbide & Carbon Corp. His headquarters will be in New York.

Elliott F. Dressner, formerly geologist with the U. S. AEC at Grand Junction, Colo. is now staff geologist, phosphate div., International Minerals & Chemical Corp., Mulberry, Fla.

Ephraim Beck Daggett is now engineer for the Vanadium Corp. of America, Naturita, Colo.

Donald Gordon Dahle has been recalled to active service by U. S. Air Force. He was formerly engineer with the Calera Mining Co., Blackbird div., Forney, Idaho.

W. L. Dotson is now associated with the New York & Honduras Rosario Mining Co., Via Jaral, Honduras.

Frederick J. Dunkerley, professor of chemical metallurgy, University of Pennsylvania, Philadelphia and **A. L. Jamieson,** metallurgist, Frankford Arsenal, Philadelphia, represented the AIME at the 55th annual meeting of the American Academy of Political and Social Science.

John A. Engstrom has joined the Australian Blue Asbestos, Ltd., Wittenoom Gorge, Western Australia.

William L. Echols is now with the Montana Phosphate Products Co., Garrison, Mont.

W. P. Druschel is plant superintendent for Michigan Limestone & Chemical Co., Worthington, Pa. His former company Pittsburgh Limestone Corp. merged with the Michigan firm.

M. Albert Evans and **M. L. Workman** have resigned from Eastern Gas & Fuel Associates, Pittsburgh. They are taking over active management of various coal mining companies in which they have been financially interested for a number of years.

K. R. Fleischman is inspector of mines, metalliferous, northern div., Herberton, North Queensland.

Louis Wright Ferguson resigned from ECA as engineer in charge of African mineral observation. He has taken the position as chief of exploration and mineral development for Casa Americana in Angola, Portuguese West Africa.

Robin B. Fermor is now acting mining superintendent of the Mina de Sao Domingos.

Michael B. Girod has joined the U. S. Steel Co., Pittsburgh, as mine superintendent of the Robena mines.

Walter F. Galloway is now mill superintendent, Mindamar, Cape Breton Island, Nova Scotia.

R. M. Hurt has been transferred from Denver to Farmington, N. Mex. by the Big Chief Western Drilling Corp.

Robert S. Hewitt is now employed by the Phelps-Dodge Corp., Morenci, as a junior engineer.

Horace B. Ham is now engineer second class for the Climax Molybdenum Co., Climax, Colo.

K. C. G. Heath has been transferred from the London office of the Anglo American Corp. of South Africa, Ltd., to the Nchanga mine in Northern Rhodesia.

D. N. Helmuth has joined the Mene Grande Oil Co., C. A., Barcelona, Anzoategai, Venezuela.

Arno C. Fieldner, former chief of the fuels and explosives div., has been named chief fuels technologist, Dept. of the Interior, Bureau of Mines. **Louis C. McCabe** is succeeding Dr. Fieldner as chief. Dr. McCabe has been assistant chief of the fuels and explosives div.

ARNO C. FIELDNER

Otto Herres, vice-president of combined Metals Reduction Co., has been named chief of the lead-zinc branch of the Defense Minerals Administration's Supply Div.

Parke A. Hodges, vice-president of Behre Dolbear & Co., New York is on a professional mission in Turkey.

A. F. Banfield has been making examinations in Wyoming and California.

Oliver B. Hopkins, vice-president, Imperial Oil Ltd., and director of petroleum div., Dept. of Defense Production, has been named president of the Canadian Institute of Mining & Metallurgy.

Cyril T. Hill is now vice-president of the Texas Gulf Sulphur Co., Inc., New York.

Gordon B. Irvine, Jr. is mining engineer over development, American Zinc, Lead & Smelting Co., Metaline Falls, Wash.

Norman W. Johnson has become associated with the General Electric Co., Fort Wayne, Ind. works laboratory.

Tage L. B. Jepsen is now with the American Smelting Boliviana, La Paz, Bolivia.

James T. Kemp is on leave from the American Brass Co., San Francisco and is on the staff of the Defense Minerals Administration, Bureau of Mines, Washington, D. C.

William G. Kane is managing director of Cia Fundidora La Concha, Mexico, D. F.

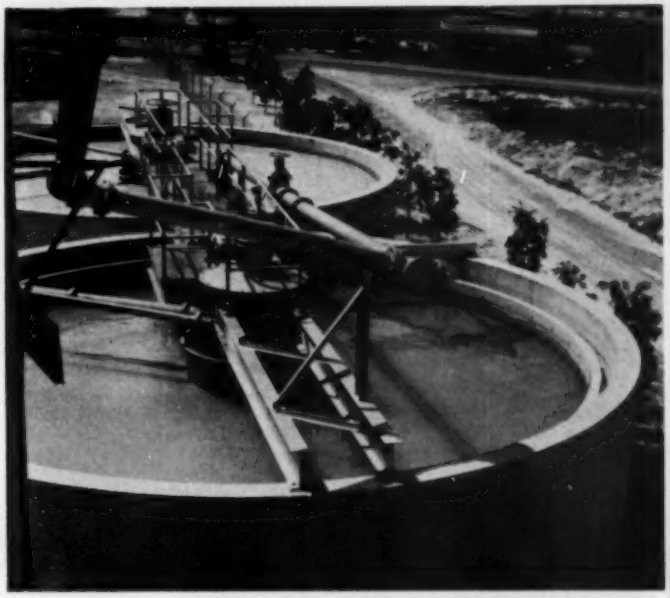
Dwight M. Lemmon, U. S. Geological Survey, Denver, is now located at Washington, D. C.

Robert W. Lawson, service engineer for Ingersoll-Rand Co. has been transferred from Butte to New York.

E. M. Lindenau has been made general superintendent of the New Idria Honduras Mining Co., Santa Rosa de Copan, Honduras.

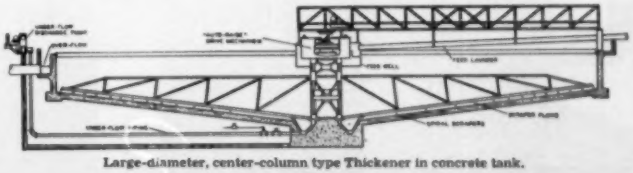
E. M. LINDENAU

HARDINGE THICKENERS PREFERRED FOR TOUGH CONCENTRATE THICKENING JOBS



Small-diameter, beam-supported Thickener mechanism

In many ore concentrators, Hardinge Thickeners are providing efficient liquid-solids separation. For instance, a typical Hardinge unit in a copper ore, pyrite, and chalcopyrite concentrating operation is dewatering and thickening 1680 tons per 24 hours of 100 mesh feed from 25% to 75% solids.
The ingenious Hardinge "Auto-Raise" Thickener drive mechanism automatically lifts the entire scraping assembly upward when an overload occurs anywhere in the tank bottom, thus preventing scraper breakage. The double spiral scrapers remove settled solids rapidly, prevent "pile-ups." Available with steel, concrete, tile or wooden tanks. Write for Bulletin 31-D-1.



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David M. Larrabee, formerly associated with Staso Milling Co., Bound Brook, N. J. is now with the Central Commercial Co., Chicago.

Robert F. Lunt is field engineer, Iron Fireman Retail Branch, Cleveland.

Simon Lake, III has joined the Bethlehem Steel Co., Bethlehem, Pa.

Tom Lyon has been named chief of the copper branch of the Defense Minerals Administration succeeding **James K. Richardson,** former manager of the Utah Mining Assn. **W. H. H. Cranmer,** president of the New Park Mining Co. is serving as a member of the advisory committee on lead.

Harold E. Lake has been made general superintendent, Port Radium Operation, Eldorado Mining & Refining (1944) Ltd., Edmonton, Alberta. He was formerly mine superintendent for the same firm.

T. S. Lovering, staff research geologist, U. S. Geological Survey has been transferred from Washington, D. C. to Denver.

Virgil Lessels is now with the Chile Exploration Co., New York.

Thomas H. McClelland has joined Pato Consolidated Gold Dredging Ltd., Barranquilla, Colombia.

James B. Morrow of Pittsburgh received a special citation from the board of directors of Bituminous Coal Research, Inc. for his "invaluable services to a great American industry." Mr. Morrow is the retired vice-president of Pittsburgh Consolidation Coal Co. and a former president of the BCR organization.

F. Newton Parks has been admitted to the partnership of Booz, Allen & Hamilton, Chicago. He is associated with the eastern region of the management consulting firm with headquarters in New York City.

Anthony L. Payne has recently been transferred from the Quirurilca Mine, Trujillo, Peru, Northern Peru Mining & Smelting Co., to the Salt Lake City office.

R. L. Prain has been elected a director of International Nickel Co. of Canada, Ltd. Mr. Prain is chairman and managing director of Rhodesian Selection Trust Ltd., Mufulira Copper Mines, Ltd., and Roan Antelope Copper Mines, Ltd.

Richard F. Pagel has been made research metallurgist for the Cerro de Pasco Corp., La Oroya, Peru.

L. C. Rhodes, Pacific Coast manager, Joy Mfg. Co., is now located in San Francisco.

John A. Ruffini of Lafayette College, Easton, Pa. was the recipient of the annual award presented at a John Markle Foundation Convocation to the outstanding senior student in mining engineering. The award is under the sponsorship of the Old Timers Club, which consists of men prominent in the coal industry.

John J. Reed has received an appointment at the University of California in Berkeley as an acting instructor in mining.

H. DANFORTH STARR

H. Danforth Starr has been elected to fill the newly created office of vice-president, Cerro de Pasco Copper Corp., New York. He will supervise the financial and accounting functions of the corporation. Mr. Starr had been assistant to the president since February 1949.

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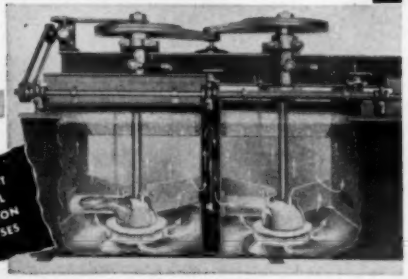

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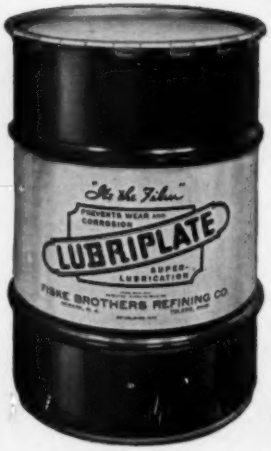

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Roy G. Stott, mining engineer with the U. S. Bureau of Mines, Wilkes-Barre, Pa. has been transferred to Birmingham.

Vernon E. Scheid has assumed his new duties as dean of the Mackay School of Mines, University of Nevada, Reno. He is also director of the Nevada Bureau of Mines and the Nevada State Analytical Laboratory. For the last several years Dr. Scheid has been chairman of the dept. of geology-geography at the University of Idaho.

Lewis E. Scott has joined the Oregon State Highway Commission in the construction dept., Salem, Ore.

Howard G. Schoenike, formerly with the M. A. Hanna Co., Iron River, Mich., is now located with the Hanna Development Co., Riddle, Ore. as geologist.

Tjeert J. C. Smid is now associated with the Belgochimie, Gent-Ghaud, Belgium. He will be in charge of a newly erected lead smelter.

R. G. Sohlberg has joined the United Geophysical Co., Pasadena. He had been associated with the Richmond Exploration Co., Maracaibo, Venezuela.

Robert Simunick is now an engineer in training for the Atlantic Refining Co., Odessa, Texas.

Neville S. Spence has been made sales manager for Dominion Magnesium Ltd., Toronto. He had been director of technical service and development for the company.

Harold L. Talbot, consulting metallurgist in Northern Rhodesia for the Anglo American Corp., is on leave in the U. S. for about six months. Mail may be addressed c/o Institute headquarters.

C. W. Westphal, technical representative of the Dorr Co. in South America, has returned to South America after a vacation in the U. S., and will be located temporarily at Apartado 1763, Lima, Peru.

Harry J. Wolf, mining and consulting engineer of New York, was recently out West examining mineral deposits in Colorado, Utah, and Wyoming.

Obituaries

Orman Pearson Brown (Member 1941) died on Jan. 18, 1951. He was one of five people aboard a plane which disappeared somewhere over the state of Wyoming. Mr. Brown was born in Montreal on Aug. 26, 1913. He came to the United States and attended Harvard and the University of Wyoming, receiving the degree of M.A. from Wyoming in 1939 and S.B. from Harvard in 1938. In 1940 he became a laboratory assistant at Harvard working on general geology. He remained there approximately one year and then joined Shell Oil Co., Inc., Denver as assistant geologist. Later he was made geologist.

L. R. Budrow (Member 1902), consulting mining engineer, died on Jan. 6, 1951. He was born in Iowa and was a graduate of the University of Iowa in 1897 and also of Missouri School of Mines, in 1899. Following graduation he was chemist and assayer for the Sierra Mojada. He was later made assistant superintendent at Parral and was also engaged in ore buying. He then joined the Montanas Mines as superintendent and in 1902 became associated with the Guggenheim Exploration Co., Chihuahua, Mexico. In 1926 he became vice-president and general manager of the Lucky Tiger Combination Gold Mining Co., Douglas, Ariz. He had also been retained by mining concerns in England, Australia, China, and other countries. At the time of his death he was residing in San Diego.

Luis F. Diaz (Member 1915), former director of Cuerpo de Ingenieros de Minas, has died. Mr. Diaz was born in Lima in 1881 and received the degree of Mining Engineer from the School of Engineers at Lima in 1906. He studied at the Facultad de Lima and was later assistant instructor at the College of San Juan, Trujillo. For several years he was employed

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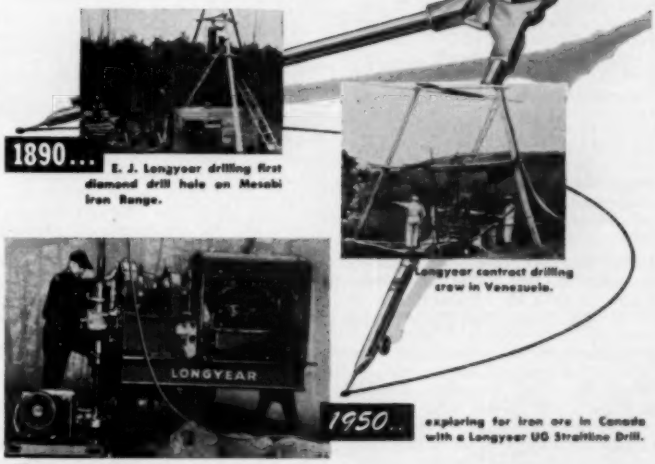

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as an engineer for various concerns, including the Cerro de Pasco Copper Co. In 1933 he joined the Cuerpo de Ingerieros de minas at Lima.

Richard Stevens Eskridge (Member 1937), consulting mining engineer, died on Dec. 4, 1950. Mr. Eskridge was born at Yuma, Ariz. in 1872 and attended schools in Detroit. He attended Harvard Law School and in 1895 received the degree of LL.B. Following graduation he took examinations and was admitted to practice law in Texas and Washington. In 1897 he left Seattle to work in the gold fields of the Dawson district in the Yukon. While in Dawson he worked in the mines, built and installed boilers and pumping plant, thawing plant and hoist. He became mining engineer for the North American Transportation & Trading Co. mines on Bonanza Creek. Several years were spent in this district and in 1901 he went to Salt Lake City and in 1910 made geological explorations in British Columbia. He was admitted to practice, U. S. District Court, Circuit Court, Circuit Court of Appeals and Supreme Court. The next eight years were spent in geological work in Alaska, W. Va. and various sections of the U. S. He was a major in the Signal Corps, Air Service, during World War I, and was discharged in 1920. Following his discharge from the Army he returned to work connected with mining and in 1921 opened the Yellowhorn mine, Grave Creek, Ore. He was consulting mining engineer for properties in various stages of development and opened his own office.

August Grunert (Member 1929) died on Feb. 18, 1951. Born in Lublin, Russia in 1887, Mr. Grunert came to the United States and attended the Montana State School of Mines. He graduated with the degree of E.M. in 1910. After graduation he was employed by the Anaconda Copper Mining Co., Butte for eight years as assayer and chemist. He was employed for several years in Montana as superintendent, assistant manager, and mill operator by various firms. In 1923 he became mill superintendent for the Jib Consolidated Mining Co., at Basin, Mont. He later was made manager and agent for the property of this firm. For several years he was engaged in consulting work and in 1939 became manager, Western Iron Works, Butte. Mr. Grunert became president of this firm and when it was sold he was again engaged in consulting work.

N. D. Levin (Member 1920) died on Nov. 26, 1950. Born in Sweden on May 29, 1867, he graduated from the Orebro Technical School in 1887. He came to the United States and in 1889 became associated with the Goodman Mfg. Co., Chicago. He had charge of all designing during the last ten years he was associated with them. In 1908 he joined the Jeffrey Mfg. Co., Columbus, as chief engineer in the mining dept. At the time of his death he was employed by this firm.

Appreciation of Jules Labarthe

By A. J. McNab

Jules Labarthe (Member, 1910) died suddenly from a heart attack on Apr. 6, 1951, at his home in Berkeley, Calif.

Mr. Labarthe was born in Peoria, Ill. Apr. 22, 1874. Following graduation from the University of Utah, he spent a brief period at Salt Lake City, working on the design of the Mercur Mill, and then moved to Trail, British Columbia, in 1896, where he attracted the attention of the officials of what subsequently became the Consolidated Mining & Smelting Co., Ltd. Starting as a draftsman, he eventually became superintendent of smelters of that organization.

In 1910 he went to Mason Valley Mines, Nev. as general manager of the company. During his tenure he designed both the mine and smelting plants, brought these into operation, and managed them until the operation shut down in the fall of 1914. From 1915 to 1925 he was a member of the firm of Bradley, Bruff & Labarthe in San Francisco. This firm, well known throughout the West, had charge of design and construction of various mill and smelting plants. Mr. Labarthe designed the Magma Copper Co. smelter at Superior, Ariz. and the Bunker Hill lead smelter at Kellogg, Idaho. When first built, both of these plants were models of up-to-date construction.

In 1925 he went to Russia to take over the operations of the Georgia Manganese Co., and as general manager completely rebuilt the mills and redesigned the operations. Returning to this country in 1928, he was employed by Hudson Bay Mining & Smelting Co., Ltd. as consulting engineer in the construction of their plants in Flin Flon. In 1930 he went to Northern Rhodesia to serve as consulting engineer in the construction of plants for the Rhokana Corp. at N'Kana. On his return to this country in 1931, he served as consultant to various mining enterprises until his retirement in 1936.

His worldwide reputation as an engineer of broad experience and sound technical ability gave only part of the picture of Jules Labarthe, the man. His quiet dignity, kindness, humor, and willingness to give friendly advice were second only to his hospitality, which was almost legendary. He had the knack of making friends, who were to be a source of continuing joy in his years of retirement. Scarcely a week passed but someone, friend or friend of a former associate, appeared from a distant part of the world to participate in the hospitality of Jules and Harriet Labarthe. To him they brought news of other friends and enterprises; from him they received the welcome of one by nature warm and generous.

He was a lover of the out of doors, a devotee of hunting, fishing and photography, but his real hobby was oology, which took him on numerous bird-egg collecting trips in Canada, Nevada, and California. His collection, now in the possession of the University of Nevada, was the envy of his fellow scientists for its completeness and its meticulous arrangement. In later years he returned to his first collecting love, philately, and as one of its specialties built an important collection of Canadian stamps.

In the death of Jules Labarthe—engineer, builder of mining enterprises, and above all, kindly gentleman—the Institute, the profession, and his host of friends have suffered a great loss.

Appreciation of Robert H. Morris

By Veleair C. Smith

Robert H. Morris, a member of the Institute since 1905 and executive vice-president and director of the Gauley Mountain Coal Co., died Mar. 1, 1951.

Bob Morris, as he was familiarly known to his friends, was born at Plattsburgh, Ohio in 1878 and graduated with an E.M. degree from Ohio State in 1901. He leaves behind him a wife, Katherine Wright Morris, whom he married at San Antonio,

(Continued on page 548)

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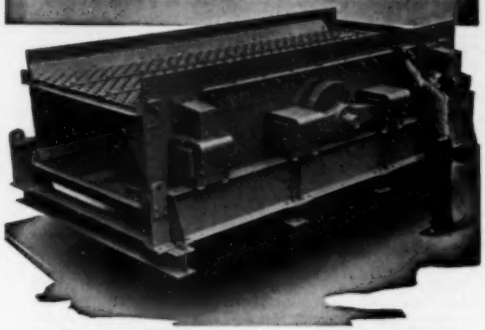

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Texas in 1908 and a daughter, Anita, and a host of friends. As a young man, he was resident engineer for Modoc Coal & Mining, 1901 to 1902; then with the Congo Coal Co. of Ohio until 1903 and Continental Coal as chief engineer until 1905. In 1905 he left Ohio to work for Roberts & Shaefer for a short time and then went to the Mexican Coal & Coke Co. at Las Esperanzas as chief engineer until 1909, when he returned to the States to take over as chief coal mining engineer of Tennessee Coal Iron & Railway Co. at Birmingham and the Jasper Park Collieries, Ltd. in Alberta, Canada. In 1917 he started with the Gauley Mountain Coal Co. as general manager. Bob was an active member and gave freely of himself to many civic, technical and other activities. In the Institute, he served as the second Chairman of the Appalachian Section, Chairman of the Coal Division and was a Director of the Institute from 1945 to 1948.

Noted for his high ethics and mental integrity, active in research and new development, he always found time to remember his friends and help young graduates in their profession. He leaves behind a notable record in management-labor relations, as well as a multitude of friends and no enemies. His friends and associates will miss him at the Institute meetings, which he faithfully attended.

Alexander Flyter Ross (Member 1930) died in October 1950. Mr. Ross was born at St. Paul, Minn. in 1881 and attended the Mining College of University of California. In 1906 he was a miner at the Kennedy Mine, Jackson, Calif. and remained with that firm in the capacities of confidential clerk, mine foreman, and then assistant superintendent. Some time was spent as superintendent for the Fremont Mine, driller on a state highway crew, and construction foreman for the California Board of Public Works. For eight years he did professional work as a mining engineer. In 1925 he returned to the Kennedy mine as personal assistant to the superintendent. Mr. Ross joined the Argonaut mine, Jackson, Calif. as superintendent in 1934. At the time of his death he was residing in Jackson.

An Appreciation of Edgar T. Rickard

By T. A. Rickard

Edgar Rickard died at the Stanford Hospital in San Francisco on Jan. 21 at the age of 77. He was born at Pontgibaud in France, where his father, Reuben Rickard was metallurgist for an important lead mining and smelting company, of which Reuben's father, James Rickard, was manager. All the men of this Cornish family were mining engineers. At one time six of them were members of the Institute. When seven years old, Edgar accompanied his father to Nevada, where Reuben Rickard had been appointed manager of the celebrated Richmond Consolidated Mining Co. When his father retired to live at Berkeley, Calif., Edgar, in due course entered the University of California from which he graduated as mining engineer in 1895. His father was the first mayor of Berkeley, and his brother Tom was mayor at the time of the San Francisco earthquake-fire. In 1900 he joined me as assistant when I was consulting engineer at Denver. In 1906 he joined me again to become business manager of the *Mining and Scientific Press* at San Francisco. At this time he married Abby Church, who proved a helpful and devoted wife for more than 30 years. Together in 1909 we started *The Mining Magazine* in London. As business manager of the two papers mentioned, he showed marked ability, his business acumen and his unfailing affability stood him in good stead. When we went to London, I introduced him to Herbert Hoover, and they became warm friends forthwith. Edgar was a member of the Commission for Relief in Belgium. He shared his chief's humanitarian feelings and won distinction for himself from the magnificent beneficence of Mr. Hoover's work in Belgium and in Central Europe. When Mr. Hoover returned to the United States, Edgar came with him to take charge of his friend's many business interests, including paper mills. During his chief's term of office as Food Administrator, Edgar was his assistant. In 1918, by Presidential order, during Mr. Hoover's absence in Europe, he was Food Administrator for nine months. His close association with Mr. Hoover continued throughout the rest of his life. Edgar worked with him in unswerving loyalty and unabated enthusiasm. In company with his chief he received many honorary degrees, the most valued of which was the LL.D. from his own University of California.

Edgar was a child when he came to the United States, and he was quick to adapt himself to the new conditions. His father had become an American citizen by naturalization, so he acquired a similar status when he came of age. His father was a Cornishman and Edgar was born in France, but as he grew to mature manhood nobody could mistake him for the man he was, an American gentleman of the best type. His courteous manners sprang from a kind heart; he was a delightful companion, a man of the highest intelligence, warmed by a touch of humor. The ending of his useful life is deeply mourned by a host of friends—Dear Old Edgar.

T. C. Russell (Member 1949) died Mar. 13, 1951. Mr. Russell was born in Almy, Wyo. in 1882. In 1900 he was employed by the Diamond Coal & Coke Co., a subsidiary of Anaconda Copper Mining Co., Anaconda, Mont. He remained with this firm for approximately seven years and then joined the Beaver Hill Coal Co. as mine superintendent. In 1915 he rejoined Diamond Coal & Coke Co. in the New York office as assistant superintendent and then he became superintendent. He was made assistant general manager of the coal dept. of Anaconda in 1924 and later appointed general manager. He went to Gabbs, Nev. in 1942 for Basic Magnesium Co. as superintendent of the mine and mill. At the time of his death he was mine and plant superintendent for the phosphate fertilizer plant of Anaconda at Conda, Idaho.

Dwight L. Sawyer (Member 1920) died on Feb. 16 after a lengthy illness. He was born at Braceville, Ill. in 1894 and moved to southern California. He attended public schools in Los Angeles and then entered Stanford University. His schooling was interrupted by service in World War I as a captain and company commander in the Combat Engineers. He returned to Stanford and graduated in geology and mining with the class of 1920. Following his graduation he was employed by various mining companies in engineering and geological work associated with the early development of properties in Colorado, Cuba, Canada, and Alaska. In 1935 he became chief engineer of the Golden Queen Mining Co., Mojave, Calif. He continued his affiliation with this company until illness forced his retirement.

Mark A. Smith (Member 1936), general superintendent and assistant general manager of El Dorado Limestone Co., died on Dec. 29, 1950. He was born in Stearns, Ky., in 1897. He held positions with various mining concerns in California, Montana, Utah, Arizona, Nevada, and Colombia, South America. In 1927 he joined the Consolidated Coppermines Corp., Kimberly, Nev. as shift boss. He later became underground boss, general mine foreman and then was made general manager. While working with the company he developed the block caving slushing method which was later patented. For the past five years he had been associated with the El Dorado Limestone Co.

Donald Steel (Member 1909) died at his home on Jan. 10, 1951. Born at Brownsville, Calif., in 1883, Mr. Steel attended Stanford University and in 1908 graduated in geology and mining. He was an assistant in applied mathematics at Stanford in 1907 and an assistant in geology and mining for two years. During the following years he was engaged in examining and consulting engineering work for various companies in

the U. S. and Alaska. In 1938 he was engineer-director for the Manhattan Gold Dredging Co., San Francisco, and opened his consulting office.

R. E. Taggart (Member 1941), president of Philadelphia & Reading Coal & Iron Co., Philadelphia died of a heart attack on May 1 at his home. Born in Leisenring, Pa., Mr. Taggart was educated at Phillips Academy, Andover, Mass. in 1906. After graduation he joined the Virginia Coal & Iron Co. He remained with this firm for 29 years. During this time he was general superintendent, general manager, vice-president and director of Stonega Coke & Coal Co. in charge of operations in Virginia and West Virginia. He was also vice-president and director of the Virginia Coal & Iron Co. From 1931 to 1935 he was vice-president in charge of operations for the Westmoreland Coal Co. with operations in western Pennsylvania. He became president and director of the Philadelphia & Reading Coal & Iron Co. in 1935. His chief contribution to the recovery of the eastern Pennsylvania industry was the establishment of the Anthracite Emergency Committee. As head of the Anthracite Operators Wage Committee, Mr. Taggart was the group's chief spokesman for several years in its wage negotiations with John L. Lewis.

Henry Thies (Member 1947) died on Jan. 11, 1951. Mr. Thies was born in Kiel, Germany in 1891 and attended the University of Kiel, graduating in 1913 with the degree of E.E. He came to the United States and in 1915 he joined the Mine Safety Appliances Co. as district sales manager. He remained with this concern until 1927 and in 1928 was part owner of the Portable Lamp & Equipment Co. In 1936 he joined Joy Mfg. Co., Pittsburgh as district sales manager.

John H. Watrous (Member 1940) died Nov. 20, 1950 of a heart attack. Mr. Watrous was born at Bellingham, Wash. on Dec. 15, 1918. He attended the University of California from 1935 to 1938, and received the degree of B.S. in geology from the University of Nevada in 1940. During the summer months he worked for the Loftus Blue Lead Mining Co., La Porte, Calif. doing assessment work and for the Oil Well Exploration & Drilling Co., Los Angeles, as a driller's assistant. Following graduation he was employed by the Loftus firm as assistant engineer. For several years he worked as a geologist in Colorado and in 1944 joined the General Petroleum Corp. of California, Craig, Colo. In 1946 he went to Mexico for the San Luis Mining Co. At the time of his death he was employed by the Calaveras Cement Co.

Charles C. Whittier (Member 1911) died on Dec. 18, 1950. Born in Somerset Co., Maine in 1876, he graduated from the University of Maine in 1899. He was employed by the Boston & Maine RR, Boston, as assistant engineer, maintenance of way. For one year he worked with a railroad company in Arizona and Mexico, and in 1901 he joined Robert W. Hunt & Co. He became chief engineer and assistant general manager for the Zeigler Coal Co., Zeigler, Ill. Several years were spent in examinations on coal, iron, zinc, and other mining properties. He was again connected with Hunt, located in Chicago. In 1940 he was president of Standard Chemical & Mineral Corp., Chicago. At the time of his death he was residing at LaJolla, Calif.

Clarence Woods (Member 1907) died after a long illness on Nov. 6, 1950. Mr. Woods was born at Grand Island, Neb. in 1881 and attended the Missouri School of Mines. In 1904 he graduated as a mining engineer and joined the Thunder Mt. Gold & Silver Mining and Milling Co. in Idaho. The next several years were spent working for various mining firms and in 1926 he went to Bolivia as manager for the Compagie Generale de Mines En Bolivia. In 1928 he became associated with the Inca Mining & Development Co. in Peru and in 1931 was president and manager of this company.

George Wilson (Member 1940) died on Nov. 25, 1950. Born at Staffordshire, England in 1884, he came to the United States and attended Ohio Northern University. He was employed by the Pittsburgh Coal Co. as transitman and by Rankin & Hengst as rodman. In 1903 he joined the National Mining Co. as transitman and engineer. In 1910 he took a leave of absence to take a special engineering course at the University and then resumed his position as a mining engineer for the same firm. He became general superintendent and advisory engineer for the Lincoln Gas Coal Co. in 1918. For three years he was engaged in supervising the development and enlargement of mine property owned by the National Mining Co. At the same time he acted as consulting engineer for the Lincoln Company visiting plants in Ohio, Illinois, West Virginia, and Pennsylvania. He was made assistant chief engineer by National, assistant general superintendent, and general superintendent, respectively. At the time of his death he was general superintendent of National Mining Co. and Sharon Coal & Limestone Co.

NECROLOGY

Date Elected	Name	Date of Death
1916	U. H. Berthier	Mar. 1, 1951
1897	William McC. Cameron	Unknown
1945	Philip L. Edwards	Mar. 17, 1951
1935	Charles Engelhard	Dec. 1950
1907	G. T. Griswold	Mar. 22, 1951
1922	L. C. Harrington	Feb. 3, 1951
1935	J. S. Hemphill	Apr. 2, 1951
1896	John Kennedy	Unknown
1910	Jules Labarthe	Apr. 6, 1951
1886	W. G. Mather	Apr. 5, 1951
1944	B. E. Moir	Feb. 7, 1951
1921	Robert H. Ogburn	Mar. 1, 1951
1907	Brent N. Rickard	Mar. 6, 1951
1949	Thomas C. Russell	Mar. 13, 1951
1930	Dwight L. Sawyer	Feb. 16, 1951
1941	R. E. Taggert	May 3, 1951
1940	John H. Watrous	Nov. 27, 1950
1940	George Wilson	Nov. 25, 1950

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Institute members are urged to review this list as soon as the issue is received and immediately write the Secretary's Office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified. Objections must be received before the 30th of the month on Metals and Mining Branches.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; AM, Associate Member; S, Student Associate.

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Ajo—Fenzi, Orazio F. (M) (C/S—A-M)
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Climax—Ziegler, Robert C. (M)

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Brewster—Lassiter, Marvin S. (M) (C/S—J-M)

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Coming Events

June 4, AIME, Mexico Section, American Club, Mexico City, Mexico.

June 6-8, Wisconsin Power Conference and Exposition, annual conference, Schroeder Hotel, Milwaukee.

June 11-15, Conference on Industrial Research, Columbia University, New York.

June 11-15, ASME, semi-annual meeting, Royal York, Toronto, Canada.

June 11-16, Armour Research Foundation of Illinois Institute of Technology. June 11-13, symposium on analysis and metallography of titanium. June 14-16, symposium on surfaces. Sheraton Hotel, Chicago.

June 15-16, AIME, Central Appalachian Section, spring meeting, Cumberland Hotel, Middlesboro, Ky.

June 18-20, American Congress on Surveying and Mapping, annual meeting, Hotel Shoreham, Washington, D. C.

June 18-22, ASTM, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

June 23, AIME, Colorado Section and San Juan and Inter-Mountain Sub-sections, Ouray, Colo.

July 2, AIME, Pennsylvania Anthracite Section, dinner-dance, Scranton Country Club, Scranton, Pa.

July 3-11, National Management Council, International Management Congress, Brussels, Belgium.

July 9-11, Idaho Mining Assn., annual convention, Sun Valley, Idaho.

July 30-Aug. 2, American Electroplaters' Society, Statler Hotel, Buffalo.

Aug. 7, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Aug. 27-Sept. 6, Oak Ridge National Laboratory and Oak Ridge Institute of Nuclear Studies, summer symposium, Oak Ridge.

Sept. 13-15, AIME, Industrial Minerals Div., fall meeting, University of West Virginia, Morgantown, W. Va.

Sept. 16-19, American Institute of Chemical Engineers, regional meeting, Sheraton Hotel, Rochester, N. Y.

Sept. 18, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Sept. 25-28, ASME, fall meeting, Radisson Hotel, Minneapolis.

Oct. 1-4, Assn. of Iron and Steel Engineers, annual convention, Hotel Sherman, Chicago.

Oct. 3-5, AIME, Petroleum Branch, fall meeting, Oklahoma City.

Oct. 9-12, Scientific Apparatus Makers Assn., mid-year meeting, Recorder-Controller Section, Seaview Country Club, Absecon, N. J.

Oct. 10-11, Joint Fuels Conference, AIME, Coal Div. and ASME, Fuel Section, Hotel Roanoke, Roanoke, Va.

Oct. 15-17, AIME, Institute of Metals Div., fall meeting, Detroit-Leland Hotel, Detroit.

Oct. 15-19, National Metal Congress & Exposition, Detroit.

Oct. 18-20, National Assn. of Corrosion Engineers, south central region, Corpus Christi, Texas.

Oct. 19-20, Engineers' Council for Professional Development, annual meeting, Hotel Statler, Boston.

Oct. 22-24, American Mining Congress, Metal and Nonmetallic Mining Convention, Biltmore Hotel, Los Angeles.

Oct. 25-26, AIME, Los Angeles Section, fall meeting, Los Angeles.

Oct. 29-Nov. 3, AIME, fall meeting, Mexico City.

Oct. 30, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Nov. 2, AIME, Pittsburgh Section, annual off-the-record meeting, Wm. Penn Hotel, Pittsburgh.

Nov. 25-30, ASME, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Nov. 28-30, Scientific Apparatus Makers Assn., midyear meeting, industrial instrument, laboratory apparatus, laboratory equipment, optical, nautical, aeronautical, and military instrument sections, Hotel New Yorker, New York.

Dec. 2-5, American Institute of Chemical Engineers, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Dec. 6-8, AIME, Electric Furnace Steel Conference, William Penn Hotel, Pittsburgh.

Dec. 11, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

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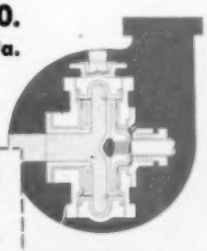

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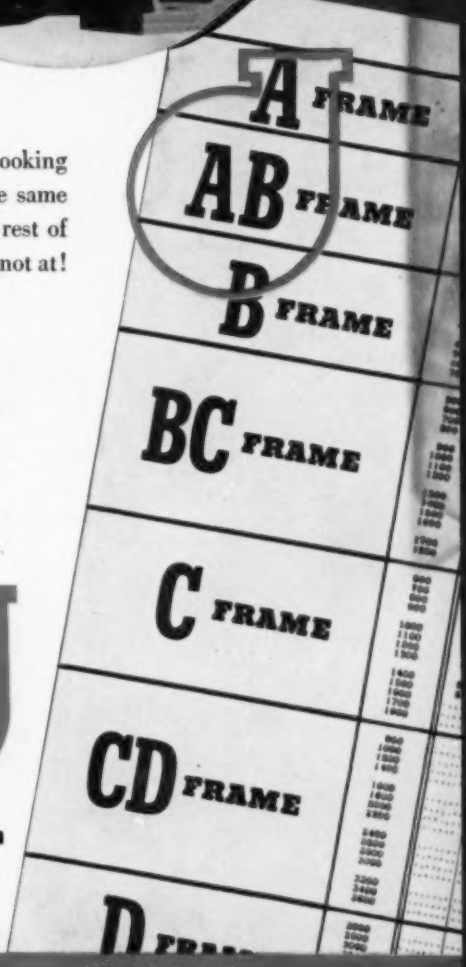

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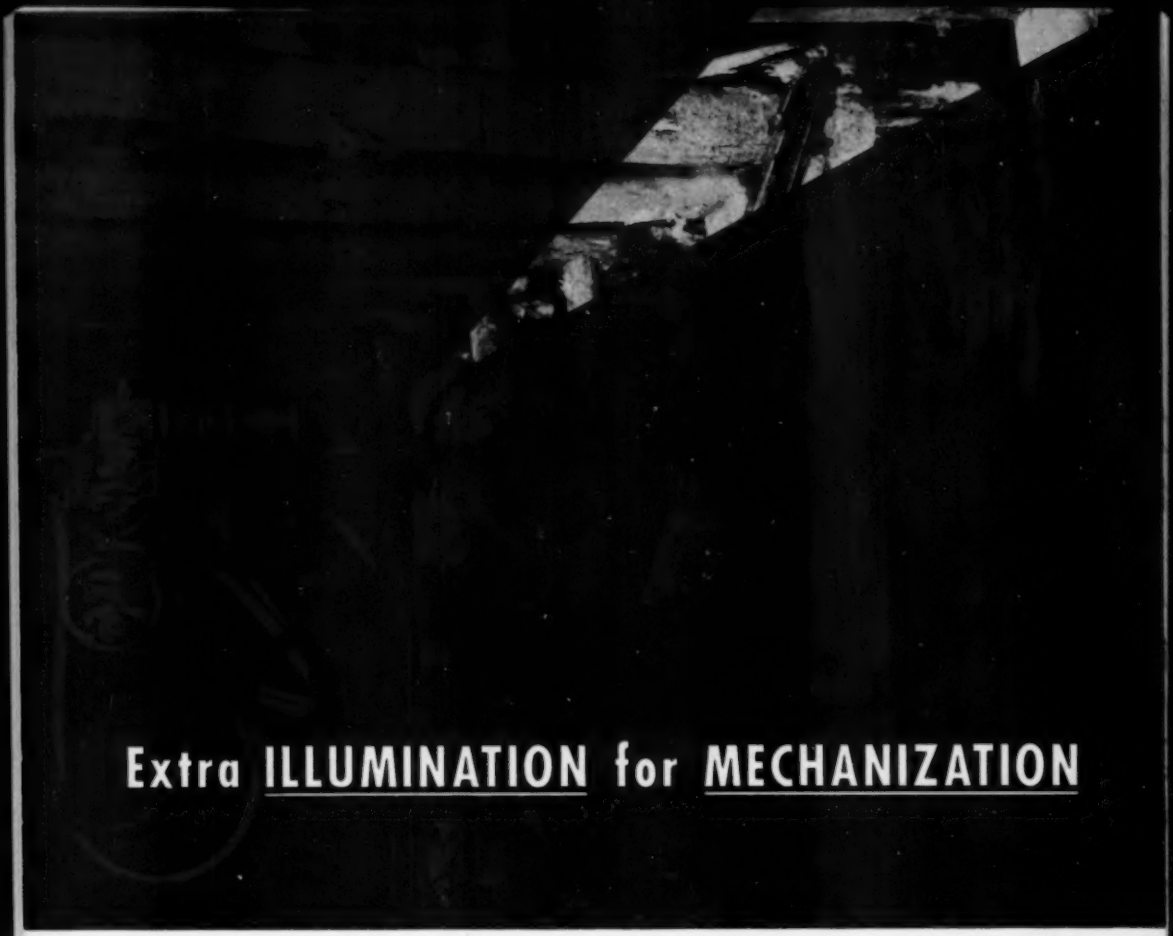

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Established as a Division February 16, 1948

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Basic Industries Research Lab.,
Allis-Chalmers Manufacturing Co.,
Box 512, Milwaukee 1, Wis.

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1951

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ESTABLISHED NOVEMBER 19, 1947

Regular meetings fourth Monday of each month except June, July, and August

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Mihiel J. Thomson, *Secretary-Treasurer*
Box 1170, Fairbanks, Alaska
H. Strandberg, *Section Delegate*

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ESTABLISHED JULY 10, 1915

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Cananea, Sonora, Mexico
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B. R. Coil
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J. A. Richards
B. N. Rickard

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AJO SUBSECTION

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William P. Crawford, *Chairman*

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E. J. Caldwell, *Chairman*
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ESTABLISHED DECEMBER 18, 1936

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Robert Hill, *Second Vice-Chairman*
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Box 834, Lead, South Dakota

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D. E. Moulds — Arthur Rice

James O. Harder, *Section Delegate*

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Nicholas J. Grant

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Plus all officers listed above

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ESTABLISHED SEPTEMBER 18, 1946

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ESTABLISHED FEBRUARY 26, 1914

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Established April 17, 1936

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F. H. Wilson, *Vice-Chairman*
William E. Milligan, *Secretary-Treasurer*
Yale University, New Haven, Connecticut

Lewis E. Thelin, *Section Delegate*

COMMITTEE CHAIRMEN

Albert I. Blank, *Publicity and Attendance*
Maur J. Weldon *Membership*

George F. Donahue, *Director-at-Large*

DELTA

Established September 18, 1946

Meets second Tuesday in the month except during June, July, and August

H. M. Krause, Jr., *Chairman*
Raymond B. Kelly, Jr., *Vice-Chairman*
Charles A. Cappa, *Vice-Chairman*
J. F. Homer, *Secretary*
Humble Oil & Refining Company
1405 Canal Bldg.
New Orleans, Louisiana

A. L. Vitter, *Treasurer*
H. O. Loehr, *Journal Secretary*
H. M. Krause, Jr., *Section Delegate*

DIRECTORS

E. N. Van Dusee — J. H. Rambin
Murray Hawkins — Fred E. Simmons, Jr.

COMMITTEE CHAIRMEN

John M. Dillon, Jr., *Activities*
H. C. Loehr, *Publicity*
J. A. Battle, Jr., *Program*
C. A. Cappa, *Membership*
L. A. J. Monroe, *House*

MISSISSIPPI SUBSECTION

J. K. Wright, Jr., *Chairman*
T. H. Jackson, Jr., *First Vice-Chairman*
S. J. Poythress, Jr., *Second Vice-Chairman*
Eugene J. Burnet, *Secretary-Treasurer*
Mississippi Oil and Gas Board
P. O. Box 347, Jackson, Mississippi

Board of Directors

J. O. Crose — R. F. Moore

DETROIT

Established February 18, 1936

Holds meetings third Monday of each month except June through September

F. Bens, *Chairman*
H. Moser, *Vice-Chairman*
E. Engle, *Secretary*
Carboloy Co., Inc.
Detroit, Michigan

B. Beckwith, *Treasurer*

R. D. Chapman, *Section Delegate*

EXECUTIVE COMMITTEE

H. Anderson — C. Gorton
F. Bens — N. Lazar
E. Dofter — M. Semchyshen
D. Frey

H. Anderson, *Chairman, Membership*

EAST TEXAS

Established April 18, 1940

Holds meetings the second Tuesday of each month except July through September

W. W. Leonard, *Chairman*
W. R. Mays, *Vice-Chairman*
W. E. LaRoche, *Secretary-Treasurer*
Tide Water Associated Oil Company
Drawer 152, Kilgore, Texas

W. W. Leonard, *Section Delegate*

DIRECTORS

Bert Crowder — P. E. DesJardins
P. J. Lehnhard — B. F. Patterson, Jr.
H. L. Long — R. K. Thies
W. S. Morris — J. A. Walker

EL PASO METALS

Established March 25, 1927

Holds meetings second Wednesday of each month

A. F. Horle, *Chairman*
C. S. Harper, Jr., *Vice-Chairman*
Guy E. Ingersoll, *Secretary-Treasurer*
Texas Western College
912 W. Yandell Blvd.
El Paso, Texas

Eugene M. Thomas, *Section Delegate*

DIRECTORS

M. S. Darbyshire — W. P. Hewitt
E. W. Donahue — W. S. Strain
M. W. Hayward — A. J. Thompson
R. L. Hennebach

COMMITTEE CHAIRMEN

O. Paul Lance, *Membership*
Hardy F. Kennady, Jack H. Nelson, *Meeting Arrangements*

Programs
March - J. F. Graham
April - R. C. Wilson
May - R. G. Ponsford, Jr.
Sept. - P. A. Alers
Oct. - E. M. Thomas
Nov. - R. J. Benson
Dec. - B. B. Kunkle
Jan. - R. J. Mellen

J. E. Despina, *Reception*

FLORIDA

Established September 27, 1949

Holds meetings the first Monday of each month

James B. Cathcart, *Chairman*
John W. Pamplin, *Vice-Chairman*
Robert Thomas, *Secretary-Treasurer*
P. O. Box 831, Plant City, Florida

Allen T. Cole, *Section Delegate*

STEERING COMMITTEE

James B. Cathcart, *Chairman*
E. T. Casler — Robert Thomas
Allen T. Cole — J. L. Weaver
N. Morris Faulds — O. H. Wright
John W. Pamplin

COMMITTEE CHAIRMEN

N. Morris Faulds, *Membership*
O. H. Wright, *Program*

GULF COAST

Established December 13, 1935

Holds meetings the third Tuesday of each month

Alfred W. Waddill, *Chairman*
George R. Gray, *Vice-Chairman*
George H. Fancher, *Vice-Chairman*
Albert B. Stevens, *Vice-Chairman*
Everett F. Stratton, *Secretary-Treasurer*
1720 Niels Esperson Bldg.
Houston 2, Texas

Julian E. Kastrop, *Section Delegate*

DIRECTORS

T. C. Borland — H. A. Otto
Julian Kastrop — E. L. Petree
E. B. Miller, Jr. — E. A. Rassinier

COMMITTEE CHAIRMEN

Fred S. Reynolds, *House*
J. S. Levine, *Activity*
W. B. Hopkins, *Membership*
K. B. Ford, *Program*
C. Leon Singleton, *Journal Editor*

KANSAS

Established November 17, 1948

Meets third Wednesday of each month except June through August

G. L. Yates, *Chairman*
J. C. Gallivan, *Vice-Chairman*
T. J. Hamilton, *Vice-Chairman*
L. W. Holsapple, *Vice-Chairman*
George J. Decker, *Secretary-Treasurer*
Schlumberger Well Survey Corp.
Box 1034, Wichita, Kansas

G. L. Yates, *Section Delegate*
J.R. Berg, *Director* — E.L. Anders, *Director*

LEHIGH VALLEY

Established March 27, 1924

R. L. Larpenteur, *Chairman*
R. B. Hoy, *Vice Chairman*
H. R. Gault, *Vice Chairman*
J. S. Marsh, *Vice Chairman*
A. F. Peterson, Jr., *Secretary*
Bethlehem Steel Co.
Bethlehem, Pennsylvania

R. G. Peets, *Treasurer*
R. T. Gallagher, *Section Delegate*

MANAGERS

M. L. Fuller R. T. Gallagher
P. W. Ramsey

COMMITTEE CHAIRMEN

R. B. Hoy & W. S. Cumings, *Program*
D. S. Lyons, *Membership*
E. B. Mancke & C. G. Tebelman, *Hospitality*
E. A. Anderson, *Student Affairs*
M. L. Fuller, *Nominations*

MID-CONTINENT

Established December 28, 1917

Holds weekly luncheon meetings each Thursday in Tulsa, Oklahoma. Regular Section Meetings held second Monday each month except June through August.

James N. McGirl, *Chairman*
Jack H. Beesley, *First Vice-Chairman (Programs)*
G. C. MacDonald, *Second Vice-Chairman (Membership)*
John H. Jennings, *Secretary-Treasurer*
Ohio Oil Company
Thompson Bldg., Tulsa, Oklahoma
Roy H. Smith, *Section Delegate*

EXECUTIVE COMMITTEE
(Tulsa)

C. H. Danchertsen M. B. Penn
A. E. Smith

Past Chairmen, ex officiis

H. M. Cooley Roy H. Smith

(Outside Tulsa)

Harold S. Kelly E. S. Messer

MINNESOTA

Established December 20, 1920

Annual meeting second week in January other meetings as called by officers

Grover J. Holt, *Chairman*
Hugh Leach, *Vice-Chairman*
W. N. Matheson, *Vice-Chairman*
E. P. Pfleider, *Vice-Chairman*
D. M. Davidson, *Secretary-Treasurer*
E. J. Longyear Company
1701 Foshay Tower
Minneapolis 2, Minnesota
Eugene P. Pfleider, *Section Delegate*

Directors

E. P. Scallon W. L. Taylor
C. J. O'Connell

MONTANA

Established October 17, 1913

Holds meetings the fourth Tuesday of each month

Kuno Doerr, Jr., *Chairman*
C. H. Steele, *Vice-Chairman*
F. W. Strandberg, *Secretary-Treasurer*
Anaconda Copper Mining Company
421 Hennessy Bldg., Butte, Montana
F. W. Strandberg, *Section Delegate*

EXECUTIVE COMMITTEE

R. H. Miller M. C. Mesmer

COMMITTEE CHAIRMEN

William Waylett, *Membership*
J. T. Roy, *Program*
Clarence Champ, *Student Awards*
A. B. Martin, *Nominating*

Chairman Advisors on Current and Desirable Subjects for Meetings

E. S. McGlone, *Mining*
M. H. Gidel, *Geology*
R. B. Caples, *Metallurgy*
A. E. Adami, *General*

NEVADA

Established January 21, 1916

Albin C. Johnson, *Chairman*
Albert Silver, *Vice-Chairman*
Andrew C. Rice, *Secretary-Treasurer*
U. S. Bureau of Mines
Box D, University Station
Reno, Nevada
J. C. Kinnear, Jr., *Section Delegate*

EXECUTIVE COMMITTEE

T. A. Copeland John Heizer
R. A. Hardy J. C. Kinnear, Jr.

RENO BRANCH

Luncheon meeting the first Thursday of each month

Clyde Collins, *Chairman*
Parker Lidell, *Secretary-Treasurer*
1500 Watt St., Reno, Nevada

NEW YORK

Established May 19, 1911

Holds monthly meetings except February, June, July, and August

Francis Cameron, *Chairman*
Philip D. Wilson, *Past Chairman*
L. C. Raymond, *Vice-Chairman*
P. Malozemoff, *Vice-Chairman*
James S. Vanick, *Treasurer*
R. H. W. Chadwick, *Secretary*
Metal Co., Ltd.
61 Broadway, New York 6, N. Y.
Philip D. Wilson, *Section Delegate*

COMMITTEEMEN

Ira K. Hearn — Domingo Moreno
H. W. Hitzrot — R. H. Ramsey
Alvin Knoerr — E. H. Thaete, Jr.

NORTH PACIFIC

Established March 28, 1913

Holds meetings third Thursday of each month except June, July and August

W. C. Leonard, *Chairman*
Drury A. Pifer, *Vice-Chairman*
A. H. Mellish, *Secretary-Treasurer*
American Smelting & Refining Company
P.O. Box 1605, Tacoma 1, Washington
M. E. Elmore, *Corresponding Secretary*
W. C. Leonard, *Section Delegate*

COUNCILLORS

Milnor Roberts — F. J. Dohrer
L. W. Heinzinger

COMMITTEE CHAIRMEN

C. H. Randt, *Membership*
H. G. Poole, *Program*

REPRESENTATIVES TO P. S. E. COUNCIL

F. J. Dohrer
Milnor Roberts

NORTH TEXAS

Established May 18, 1945

Jack A. Crichton, *Chairman*
K. Marshall Fagin, *Vice-Chairman*
Gus Athanas, *Vice-Chairman*
Earl C. Taylor, Jr., *Vice-Chairman*
Kenneth F. Anderson, *Secretary-Treasurer*
Bureau of Mines, Dallas, Texas
Jack A. Crichton, *Section Delegate*

DIRECTORS

Joab B. Harrell, Jr. — Pat Reardon
R. G. Parker — W. E. Stiles
Gordon R. Stine

OHIO VALLEY

Established November 19, 1920

John H. Melvin, *Chairman*
Richard J. Lund, *Vice-Chairman*
William H. Smith, *Secretary-Treasurer*
Ohio Division of Geology Survey
Orton Hall, Ohio State University
Columbus, Ohio
W. A. Mueller, *Section Delegate*

COMMITTEE CHAIRMEN

James W. Cunningham, *Program*
William H. Newton, *Membership*
Arthur Westerman, *Member Representative*

AREA REPRESENTATIVES

B. M. O'Harra, *Cincinnati*
George R. Long, *Dayton*
G. W. Noble, *Findlay*
Max A. Tuttle, *Indianapolis*
Cecil E. Bales, *Ironton*
Harold P. Gow, *Middletown*
Theron W. Reed, *Newark*
Benjamin Eggers, *Portsmouth*
James D. Reilley, *St. Clairsville*

OKLAHOMA CITY

Established February 18, 1947

J. H. Field, *Chairman*
J. C. Cordell, *First Vice-Chairman*
R. M. Caywood, *Second Vice-Chairman*
M. J. Popovich, *Secretary-Treasurer*
Sohio Petroleum Company
Skirvin Tower, Oklahoma City, Oklahoma

J. H. Field, *Section Delegate*

DIRECTORS

Henry Waszkowski — J. W. Maly
Edward Saye, III

OREGON

Established April 22, 1921

Holds meetings third Friday of each month except during summer months

David H. Beetem, *Chairman*
Stephen M. Shelton, *Vice-Chairman*
Albert O. Bartell, *Past Chairman*
James Forbes Bell, *Secretary*
Portland Gas & Coke Company
Public Service Bldg.
Portland 4, Oregon

D. H. Beetem, *Section Delegate*

EXECUTIVE COMMITTEE

A. O. Bartell — J. McWilliams
D. H. Beetem — Ernest Messer
J. F. Bell — S. M. Shelton

L. H. Banning, *Membership Chairman*

PENNSYLVANIA-ANTHRACITE

Established February 17, 1914

Holds meetings alternately at Pottsville, Hazleton, Wilkes-Barre and Scranton. Spring meeting, April; Summer meeting, July; Fall meeting, October.

Henry A. Dierks, *Chairman*
D. C. Helms, *Vice-Chairman*
Floyd S. Sanders, *Secretary-Treasurer*
Goodman Manufacturing Company
35 New Bennett Street
Wilkes-Barre, Pennsylvania

Cadwallader Evans, Jr., *Section Delegate*

EXECUTIVE COMMITTEE

John W. Buch — Earl W. Lamb
George J. Clark — William C. Muehlof
E. L. Dana — W. Julian Parton
William W. Everett — Walter B. Petzold
Edward G. Fox — James H. Pierce
Carroll A. Garner — Edward T. Powell
J. M. Humphrey, Jr. — John M. Reid
Wilmot Jones — George A. Roos, *ex officio*

J. T. Griffiths, *Membership Chairman*

PERMIAN BASIN

Established November 14, 1945

Jack M. Moore, *Chairman*
Joe Chastain, *Vice-Chairman*
Ray Easterhaut, *Secretary-Treasurer*
Dowell, Inc.
409 W. 21 St.
Odessa, Texas

Jack M. Moore, *Section Delegate*

BOARD OF DIRECTORS

Bryan Denson — Ray Howard
W. N. Little

COMMITTEE CHAIRMEN

T. C. Frick, *Welcoming*
Ray Howard, *Program*
J. T. Lewis, *Membership*

SOUTH PLAINS SUBSECTION

R. W. Coburn, *Chairman*
J. B. Rosen, *First Vice-President*
John Gould, *Second Vice-President*
K. D. Snedeker, *Secretary-Treasurer*
Kobe Inc., Box 849,
Brownfield, Texas

PHILADELPHIA

Re-established March 15, 1944

Dinner and meeting held last Thursday each month except June through September

A. L. Jamieson, *Chairman*
D. Finch, *First Vice-Chairman*
A. A. Bradd, *Second Vice-Chairman*
F. J. Dunkerley, *Secretary-Treasurer*
University of Pennsylvania
247 Engineering Bldg.
Philadelphia, Pennsylvania

A. L. Jamieson, *Section Delegate*

EXECUTIVE COMMITTEE

C. B. Allen — A. L. Jamieson
A. Bounds — F. B. Litton
A. W. Grosvenor, *Ex officio*
F. Foley, *Ex officio*

PITTSBURGH

Established 1920

G. J. Donaldson, *Chairman*
R. F. Miller, *Vice-Chairman*
E. H. Hollingsworth, *Secretary*
Aluminum Research Laboratories
Aluminum Co. of America
New Kensington, Pennsylvania

R. D. Snouffer, *Treasurer*
Linwood Thiessen, *Section Delegate*

EXECUTIVE COMMITTEE

N. G. Alford — D. T. Rogers
H. G. Botset — D. W. Pettigrew, Jr.
A. J. Breitenstein — J. T. Ryan, Jr.
G. Derge — W. G. Stevenson
S. Feigenbaum — C. H. Sawyer
H. P. Greenwald — J. M. Stewart
M. G. Gulley — Linwood Thiessen
J. B. Morrow — W. L. Wearly
A. B. Wilder
Ex Officiis
H. N. Eavenson — L. E. Young

S. Feigenbaum, *Chairman*
Annual All-Day Off-the-Record
Technical Session

ST. LOUIS

Established May 23, 1913

Norman Hinchey, *Chairman*
Curtis Wilson, *Vice-Chairman*
Nat L. Shepard, *Past-Chairman*
John D. Kerr, Jr., *Secretary-Treasurer*
St. Louis Chamber of Commerce
511 Locust Street
St. Louis, Missouri

Clyde S. Smith, *Section Delegate*

EXECUTIVE COMMITTEE

Howard I. Young — O. M. Bishop
Carl G. Stifel — Ernest L. Ohle
John E. Lamar — Clyde Smith

Howard E. Butters, *Program Chairman*

SAN FRANCISCO

Established June 26, 1913

Holds meetings second Wednesday of each month except June through August; and Monday noons for luncheon at Engineers' Club

George H. Playter, *Chairman*
Walter L. Penick, *Vice-Chairman*
J. G. Huseby, *Secretary-Treasurer*
Room 700, 216 Pine Street
San Francisco 4, California

E. H. Wisser, *Section Delegate*

COMMITTEE CHAIRMEN

Walter L. Penick, *Program*
J. C. Lokken, *Membership*
Edward Wisser, *Student Contact*
Granville S. Borden, *Tax*
Bernard York, '52, *Student Prize*
Lawrence B. Wright, *Licensing*

Granville S. Borden,
Entertainment and Hospitality

W. Spencer Reid, *Advisory*

A. A. Hoffman, *Finance*

H. A. Sawin, *Nominating*
Edward W. Ballard,
Advisory Committee of Eng. Society Employment Service

Philip R. Bradley, Jr., *Legislative*

W. W. Hein, Jr., *Engineering Council*

SOUTHEAST

Established February 18, 1936

W. C. McKenzie, *Chairman*
E. H. Rose, *First Vice-Chairman*
Alfred Shook III, *Second Vice-Chairman*
Wayne L. Dowdey, *Secretary-Treasurer*
Elmco Corporation
3140 Fayette Ave., Birmingham, Alabama
W. C. Chase, *Section Delegate*

DIRECTORS

W. C. Chase — Hugh Kendall
P. G. Cowin — Nelson Severinghaus
Wm. Black — R. H. Hopkins

COMMITTEE CHAIRMEN

M. C. McCall, *Membership*
C. H. Dewey, *Program*
Monro B. Lanier, II, *Entertainment*
Howard Cobb, *Publicity*
J. W. Stewart, *Development of Jr. Engineers*
E. H. Stevens, *Student Counselor*
C. H. Dewey, *Representative*
Birmingham Engineers Council

SOUTHERN CALIFORNIA

Established May 23, 1913

J. A. Kavenaugh, *Chairman*
P. A. Haythorne, *Secretary*
2521 Rinconia Ave.
Los Angeles 26, California
C. W. Six, *Treasurer*
J. A. Kavenaugh, *Section Delegate*

DIRECTORS

John Risley, *Metals Branch*
Richard Stewart, *Mining Branch*
Basil Kantzer, *Petroleum Branch*
Ian Campbell, *Past Chairman Mining Branch*

SOUTHWESTERN ALASKA

Established February 1951

SOUTHWEST TEXAS

Established September 18, 1946

Holds meetings second Wednesday of each month except July, August and December

Lee J. Thronson, *Chairman*
George Wilson, *Vice-Chairman*
Harry D. Vaughan, *Secretary-Treasurer*
Lane Wells Co., P. O. Box 389
Corpus Christi, Texas
Lee J. Thronson, *Section Delegate*

DIRECTORS

B. Booth	Henry Kerr
J. M. Clark	Carl Peters
R. C. Granberry, Jr.	Frank Saye
F. Hebert	D. F. Shaw
C. W. Kelley	Chester Wheless

COMMITTEE CHAIRMEN

C. L. Wheless, *Membership*
D. F. Shaw, *Program*

SAN ANTONIO-AUSTIN SUBSECTION

W. H. Spice, Jr., *Chairman*
H. H. Powers, *Vice-Chairman*
J. B. Jones, *Secretary-Treasurer*

DIRECTORS

Oscar Goode	W. E. Richards
J. H. McQueen	Harry Rosser

SOUTHWESTERN NEW MEXICO

Established September 30, 1947

Holds meetings second Wednesday in January, April, July and October

T. Alfred Snedden, *Chairman*
Jerry W. Faust, *First Vice-Chairman*
Robert M. Hernon, *Second Vice-Chairman*
David W. Boise, *Secretary-Treasurer*
917 West Street
Silver City, New Mexico

COMMITTEE CHAIRMEN

W. J. Akert, *Membership*
Elton Clark, *Program*

TRI-STATE

Established May 27, 1926

Ernest Blessing, *Chairman*
Joseph P. Lyden, *Vice-Chairman*
William F. Netzeband, *Secretary-Treasurer*
Box 870, Joplin, Missouri
Dan Stewart, *Section Delegate*

DIRECTORS

Ernest Blessing	H. A. Krueger
S. S. Clarke	Joseph P. Lyden
F. J. Caddeback	William F. Netzeband
George M. Fowler	Jacob C. Stroup

COMMITTEE CHAIRMEN

F. J. Caddeback, *Membership*
S. S. Clarke, *Program*

UPPER PENINSULA

Established October 25, 1918

A. J. Christenson, *Chairman*
Robert K. Poull, *Vice-Chairman*
Roy W. Drier, *Secretary-Treasurer*
College of Mining & Technology
715 Pine St., Calumet, Michigan
P. P. Ribotto, *Section Delegate*
Roy W. Drier, *Alternate*

ADVISORY COMMITTEE

F. W. Denton, Jr.

COMMITTEE CHAIRMEN

A. J. Christenson, *Executive*
Carl Brewer, *Nominating*
Roy W. Drier, *Finance*
Roy W. Drier, *Program*
Fred W. Denton, *Membership*
A. K. Snelgrove, *Student Relations*
W. A. Knoll, *Entertainment*
Roy W. Drier, *Publicity*
F. E. Brown, *Professional Standards*

UTAH

Established April 24, 1944

Carlos Bardwell, *Chairman*
W. G. Reuillard, *Vice-Chairman*
Harry P. Allen, *Secretary-Treasurer*
1316 Penn Street
Salt Lake City,S, Utah
B. E. Grant, *Section Delegate*

EXECUTIVE COMMITTEE

C. J. Christensen — M. B. Kildale
J. M. Ehrhorn — H. L. Johnson

COMMITTEE CHAIRMEN

J. F. Dugan, *Membership*
Burt B. Brewster, *Publicity*
Robert S. Lewis, *Student Affairs*
E. Kipp, *Entertainment*

WYOMING

Established May 16, 1930

Holds regular meetings quarterly; special meetings when speakers are available.

Frank J. Peternell, *Chairman*
H. G. Fisk, *Vice-Chairman*
Frank Kratka, *Secretary-Treasurer*
Union Pacific Railroad Company
Box 1072, Rock Springs, Wyoming
Frank J. Peternell, *Section Delegate*
I. N. Bayless, *Alternate*

EXECUTIVE COMMITTEE

I. N. Bayless — I. M. Charles
G. B. Pryde

MEMBERSHIP COMMITTEE

W. T. Nightingale, *Chairman*
V. O. Murray

WASHINGTON, D. C.

Established June 21, 1918

Holds meetings usually third Tuesday of each month except June through August

Paul M. Tyler, *Chairman*
R. B. McCormick, *Vice-President for D.C.*
Charles E. Stott, *Vice-President for Maryland*
Julian W. Feiss, *Vice-Chairman for Virginia*
J. W. Clark, *Secretary-Treasurer*
U. S. Bureau of Mines, Dept. of the Interior
Washington 25, D. C.
F. T. Moyer, *Section Delegate*

EXECUTIVE COMMITTEE

A. W. Dickenson — Henry C. Morris
R. L. Wilcox

FOREIGN SECTIONS

MEXICO

Established 1950

Holds monthly luncheon meetings first Monday of each month at American Club, Mexico City

Alfredo Terrazas, *Chairman*
Valentin Garfias, *Vice-Chairman*
William G. Kane, *Secretary-Treasurer*
P. O. Box 711, Mexico City, D.F.

PHILIPPINE

Established January 20, 1939

Nestorio N. Lim, *Chairman*
Ananias Crisostomo, *Secretary-Treasurer*
157-A Mayon St.
Quezon City, P.I.

RIO DE JANEIRO (Brazil)

Established April 17, 1936

Holds meetings Thursday of each month at Av. Rio Branco 128, Room 410

E. de Macedo Soares S., *Chairman*
A. I. de Oliveira, *Vice-Chairman*
Harvey Hakala, *Vice-Chairman*
Frank E. Noe, *Secretary*
Silvio Froes Abreu, *Secretary*
Instituto Nacional de Tecnologia
Rio de Janeiro, Brazil
H. C. Alves de Sousa, *Treasurer*

STUDENT CHAPTERS

1951

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STUDENT CHAPTER, AIME
Sigmund L. Smith

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THOMAS THORNTON READ SOCIETY
Herbert H. Kellogg

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CORNELL METALLURGICAL SOCIETY
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